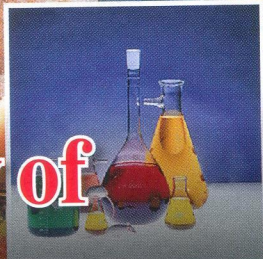
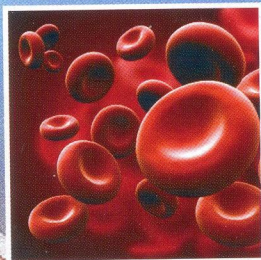
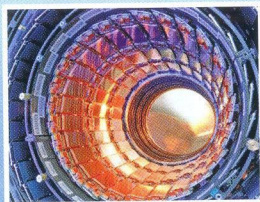


MANORAMA

TELL ME WHY

No:72



The Story of Science

100 + FACTS ABOUT THE MILESTONES OF SCIENCE





A 'FLYING' MAGNET!

A magnet hovers above super conductor. The magnetic field produced by the current flow in the super conductor repels the magnet and makes it 'fly' above! 'Super Conductivity' has become one of the main areas of modern Physics.

MANORAMA
TELL ME WHY

From the house of MAGIC POT, MANORAMA YEAR BOOK, VANITHA,
THE WEEK & THE MALAYALA MANORAMA DAILY

September 2012

Volume: 6

No: 12



Man's Greatest Achievement

The history of science tells us the thrilling story of how human intellect developed. The word 'science' originates from the Latin word 'scientia', which means knowledge. However, science as we know it now, is not just a collection of bits of knowledge. On the other hand, it refers to a systematic way of building up, organizing, and handling knowledge in the form of testable explanations and predictions.

'Why?' is the basic question that led to the great enquiries of science. Early Man wondered about everything he saw around him. The rising sun, the thundering storm clouds, the twinkling stars – all these brought countless questions into his mind, and science came to be.

Great scientific minds put together related facts, drew up general principles, and thus paved the way for scientific thinking.

It would obviously be impossible to carry all the epoch-making feats of science in a single issue of Tell Me Why. In this issue, we have included some questions related to physics, chemistry, biology and geology. Questions related to mathematics - the queen of all sciences- will be published in a later issue.

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Fax: ++91- 481 - 2564393
E mail: subscription@mmp.in
childrensdivision@mmp.in

NEW DELHI: Malayala Manorama Co. Ltd.,
Andhra Vanitha Mandali Building,
2, Azad Bhavan Road, Indraprastha Estate,
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Phone: 011- 23379718, 23379719, 23379720

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A- 404 Marathon Innova, A Wing 4th Floor,
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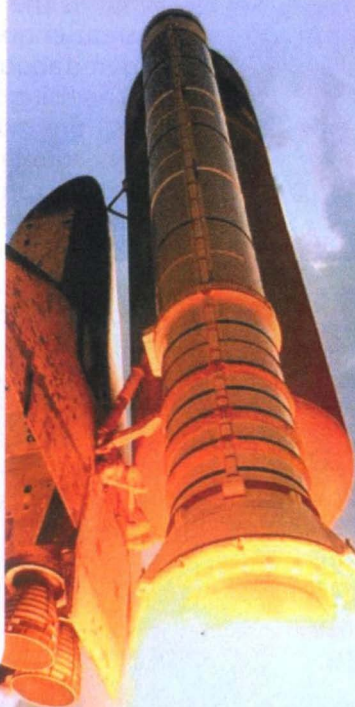
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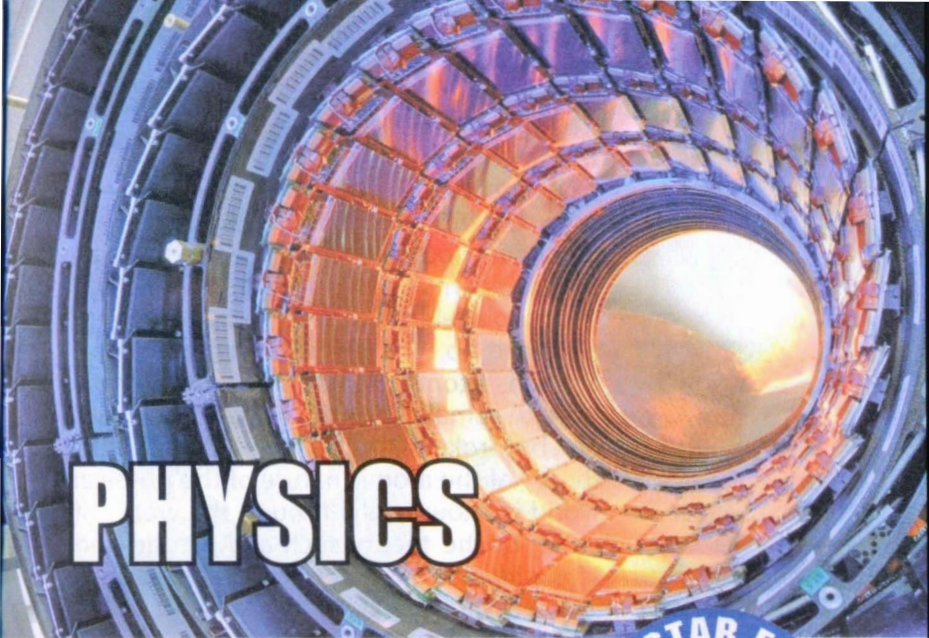
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THE STORY OF SCIENCE





PHYSICS

Why is physics an ancient science?

In very early times, Man attributed the wonders of nature to the gods. However, around the first century before the birth of Christ, there was an intellectual awakening in the ancient Greek colonies. The philosophers of the time realized that the Universe exhibited an order, and followed certain rules. Around 450 BC, Empedocles, an ancient Greek philosopher and poet, first put forward the idea that all matter is composed of four essential elements—fire, air, water, and earth. He used a clepsydra, a vessel with a hole at the bottom, and one at the top, to prove that air existed. He was one of the first to conduct an experiment to prove a scientific theory.



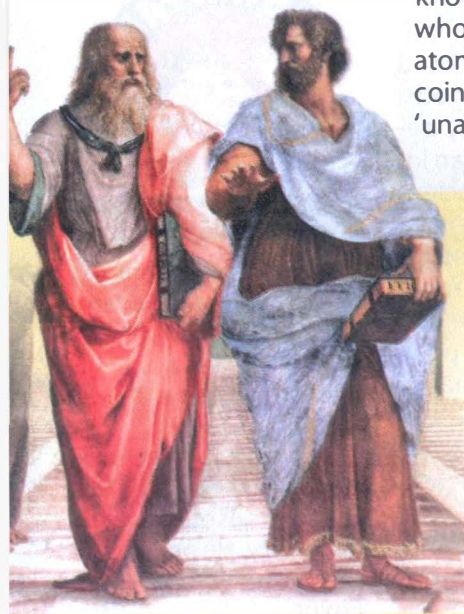
Hero of Greece

Thales is remembered as one of the first of Seven Wise Men of Ancient Greece. He was a mathematician and astronomer, who predicted a solar eclipse, and is credited with five theorems of elementary geometry. He measured the pyramids of Ancient Egypt.

Why is Democritus significant in the history of physics?

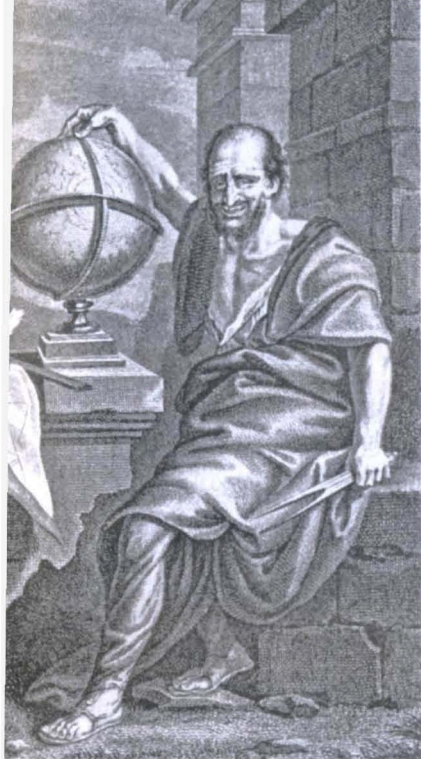
Democritus, who lived in Northern Greece between 460 and 370 BC, is famous for his great contributions to science. He appears to have spent all of his time in scientific and philosophical studies, teaching, and writing. He came up with the idea that all matter contains atoms. He reasoned that atoms were the smallest part of matter, and could not be broken down further. Democritus' theory of the atomic nature of the physical world is known only through the works of critics of the theory such as Aristotle and Theophrastus. However, his work was largely ignored for almost 2000 years. He is acknowledged today as the person who laid the foundation for the atomic theory of matter. He also coined the word 'atom,' which means 'unable to cut,' in Greek.

Plato and Aristotle



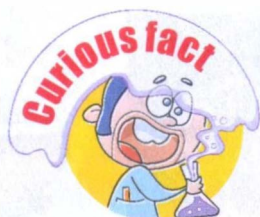
Three Philosophers

The three great philosophers of Ancient Greece lived during the 4th century BC, during the reign of Alexander the



Democritus

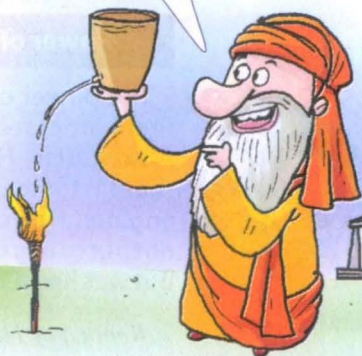
Great. They were Plato, Socrates, and Aristotle. Socrates was Plato's teacher. Plato in turn, was Aristotle's mentor. Aristotle believed that by observing a natural phenomenon, one could also arrive at the laws governing Nature. He rejected the theory of the atom, and said that all matter is made up of five elements.

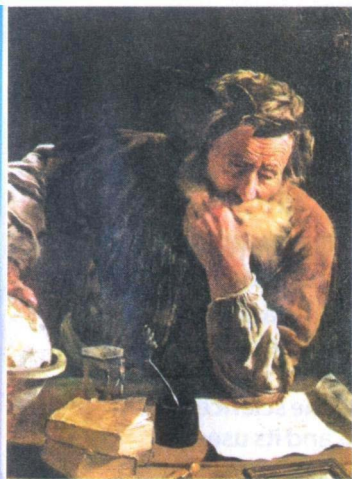


Master of Air Devices

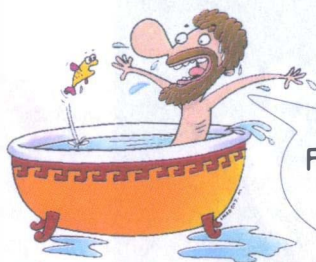
Ctesibius of Alexandria, Egypt, was a Greek physicist and inventor. He wrote the first treatises on the science of compressed air, and its uses in pumps, and even the cannon. Ctesibius is also known for his improvement of the water clock.

Fire, air,
water, and earth.
This year's scientist
award will undoubtedly
be mine!





Archimedes



Eureka..!
Found the fish
for today's
meal!

Why is Archimedes described as the first mathematical physicist?

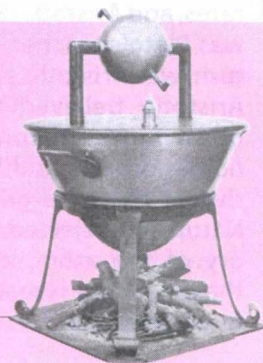
Archimedes lived in Syracuse between 290 and 80 BC. He used mathematics to solve many of the problems of physics. He established the concept of the centre of gravity, and dealt with the equilibrium of floating objects. Archimedes is most famous for his principle that states that any body completely or partially submerged in a fluid at rest is acted upon by an upward force. The magnitude of this force is equal to the weight of the fluid displaced by the body. Archimedes' principle explains why a ship made of iron floats, even though iron sinks in water. Archimedes is supposed to have made this discovery when stepping into his bath, and it is said that he was so excited that he ran home naked, shouting 'Eureka,' which means 'I found it'!



Power of Steam

The power of steam was first harnessed by Hero of Alexandria. He invented the first steam powered engine. However, it was not put to any practical use, but was just a toy.

Replica of Hero's Engine



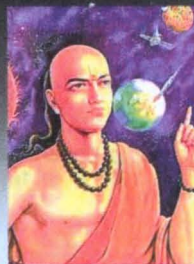
Why is it said that physics made great strides in Ancient India and China?

In the 6th century BC, an Indian philosopher named Kanada developed an atomic theory. The theory of dyads and triads, and the molecular theory of matter were also put forward in Ancient India. Ancient Indian philosophers were the first to suggest that light and sound travelled in waves, and they put forward the theories of reflection and refraction of light. One of them, They theorized that light itself was made up of small particles-now known as photons. Ancient India also made great contributions to astronomy. The Earth was assumed to be the centre of the Universe around which revolved the seven grahas or planets. Varahamihira and Aryabhatta were two of the great astronomers of Ancient India.

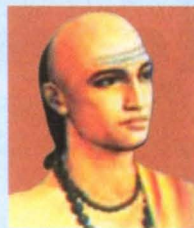
In China, Zhang Sui was a great astronomer who constructed new astronomical instruments in collaboration with Liang Lingzam in 724 AD. In 1045, Chinese astronomers sighted the Crab Nebula, and in 1280, Kuo Shou-Ching another great astronomer, introduced improved astronomical instruments.



Zhang Sui



Aryabhatta



Varahamihira

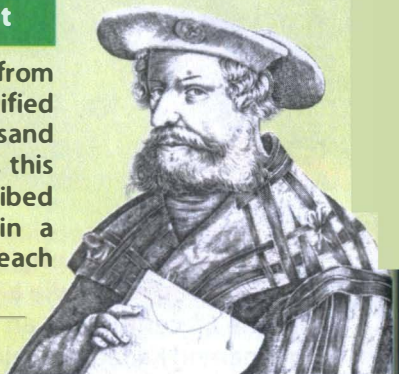


Star Scientist

Ptolemy from Greece identified over a thousand stars. In AD 964, this

list was revised by Al-Sufi. He described their position, size, and brightness in a book which had two drawings of each constellation.

Ptolemy



Why is the development of ancient astronomy fascinating?

Man has always loved gazing up at the stars, and wondering about them. This led to the development of astronomy in ancient times.

The ancient Egyptians and Babylonians developed a fairly accurate calendar of astronomical observations and predictions.

In the 5th century BC, the Pythagoreans developed a model of the solar system. Heracleides Ponticus suggested that the planets revolve around the sun. He believed that the sun revolved around the Earth, which was rotating on its axis.

Aristotle too believed that the Earth was the centre of the Universe, with the planets and stars surrounding it in concentric circles.

Change this picture!
Earth is the centre of the Universe.





Pythagoras

Trigonometric tables were developed by Hipparchus. He also put forward the concept of equinoxes. Ptolemy was also a great astronomer of ancient times.



Revealing Secrets

Forty planetary conjunctions and thirty lunar eclipses, and more than ten thousand entries for the sun's position for many years, were all recorded by Ibn Yunus.

What do we know about the development of physics in the Arab world?

The torch of learning passed into the hands of scholars of Arab world during the dark Ages of Europe in the 7th century. Arabic translations were made of Greek scientific works. Thabit ibn Qurra, proved the principle of the equilibrium of levers and proposed a theory of motion. The most comprehensive work during this period was written by Abd al-Rahman al-Khazin in 1121, and called 'The Book of the Balance of Wisdom'. It discussed the history of statistics and hydrostatics.



Thabit ibn Qurra

Take a long sheet of paper! that one's not long enough to write the circumference of Earth.



Zij

Zij is the name of the Arabic astronomical tables. These tables are used to calculate the position of the Sun, Moon, stars and planets.

What do you know about the growth of physics in medieval Europe?

Galileo Showing his Telescope to Senators



During the Middle Ages of Europe, science took a back seat. However, awareness of ancient works re-entered the west through translations from Arabic to Latin.

European scholars considered Aristotle to be the greatest thinker of the ancient world. It was believed that celestial objects moved in circles while earthly objects moved in straight lines towards the centre of the Earth.

Experiments were not encouraged, and many

Tell Me Why

Curious fact



The Renaissance

The re-discovery of ancient scientific texts in 1453, revived an interest in science.

This interest was further stimulated by the invention of printing, which allowed ideas to spread faster. Paolo Nicoletti, Nicholas of Cusa, and Leonardo da Vinci, are all great men of the time whose inquiring minds sparked the Renaissance of science in the 16th century.



Galileo's Telescope

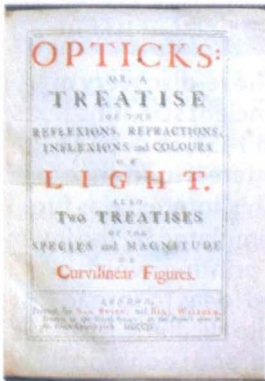
did not consider them a valid means of learning about the natural world.

In short, the spirit of scientific inquiry appeared to be dormant during this period in Europe.

The Story of Science



An Early Model of the Solar System with Earth at its centre.



*Newton's 'Opticks' -
The First Edition*



Euclid - A Painting

When was optics considered a separate discipline of science?

Optics is the scientific study of sight, and the behaviour of light. The first theory of vision was developed by Euclid around 300 BC, and this was the beginning of optics as a separate science. Euclid believed that the eyes emitted light in the shape of a cone that had its vertex in the centre of the eye, and its base on the object seen. Al-Kindi studied the propagation of light, the formation of shadows, and the principles of radiation.

In AD 984, Ibn Sahl studied the laws of refraction. Ibn al-Haytham initiated a revolution in optics when he rejected the ancient theory that vision occurs by the emission of light rays from the eye. He stated that vision occurs when eyes receive the light rays reflected from objects-and proved it by experimental demonstration.



Statue of Euclid



Johannes Kepler

Johannes Kepler was a German astronomer who observed that the planet Mars had an elliptical orbit with the sun as its focus. He established the laws of elliptical orbits, and his theory was that the sun exerted a magnetic force that kept the planets moving in their orbits. He is remembered as the scientist who brought astronomy and physics together.

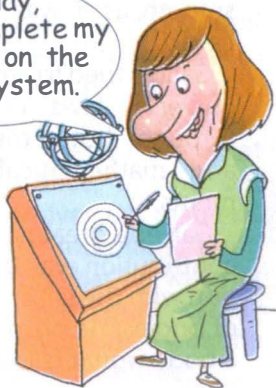


Copernicus - A Painting

Why is Copernicus an important figure in astronomy?

For hundreds of years, most scholars had believed that the sun, stars, and planets revolved around Earth. But they were mistaken. It was Nicolaus Copernicus who changed all that. Copernicus studied mathematics, law, and medicine. His interest in astronomy grew in and around 1517. He came up with a radical way of looking at the Universe. His theory was that the Earth rotates daily on its axis, and revolves around the Sun yearly. Known as the heliocentric system, it challenged the existing theory known as the geocentric system, which stated that the Earth was the centre of the Universe. Copernicus' ideas were too different for most of the scholars of his time to accept.

Today,
I will complete my
project on the
solar system.



Why is Galileo called the 'father of modern physics'?

Galileo Galilei was referred to as the father of modern astronomy and physics. Galileo was one of the first to improve the telescope enough to use it to observe the sky. He discovered four of Jupiter's largest satellites, and his observations of the moons of Jupiter re-

Look, that's not a star, that's Jupiter.



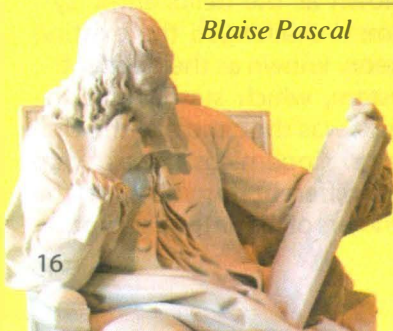
Torricelli and Pascal

Torricelli was a physicist and mathematician who assisted

Galileo. It was Galileo who suggested to Torricelli to use mercury in his vacuum experiments, and this enabled him to create a sustained vacuum, and to discover the principle of the barometer.

Blaise Pascal replicated Torricelli's mercury experiment, and proved that air has weight.

Blaise Pascal



volving around the large planet, and Venus orbiting the sun, lent support to Copernicus' heliocentric theories.

Galileo also discovered that the Milky Way was made up of millions of stars, and that the Moon's surface was rough and cratered, and not smooth as it was then believed.

Galileo tried to arrive at the universal laws of motion through both mechanical and mathematical experiments.

Galileo's greatest scientific contribution was in connection with the fall and motion of bodies. He proposed that a body would fall with a uni-

Tell Me Why



Rene Descartes

Rene Descartes used questions to find truth. In Descartes' vision of the Universe, God set matter in motion- and according to the principle of inertia, matter, once set in motion, cannot stop, but must continue to move in a straight line until something else stops it.



Galileo Galilei

form acceleration, provided that it is falling through a vacuum, or there is no resistance.

To sum up, Galileo was the first astronomer to use what we call science, to find out what the Universe is made of. The most important thing about him is that he was not guessing. He could clearly prove to anyone that what he had discovered was true.

The Story of Science

What is the role played by Isaac Newton in physics?

Sir Isaac Newton is one of the most influential scientists of all time. He came up with numerous theories, and contributed ideas to many different fields including physics, mathematics, and philosophy. He used experimental and mathematical meth-



ods to explain natural phenomena. In 1687, Newton published the book 'Principia', which is widely regarded as one of the important books in the history of science. In it, he describes universal gravitation and the three laws of motion, concepts that remained at the forefront of science for centuries after. His law of universal gravitation describes the gravitational attraction between bodies with mass, the Earth and Moon. Newton was known to have said that his work on the theory of gravitation was inspired by watching an apple fall from a tree!



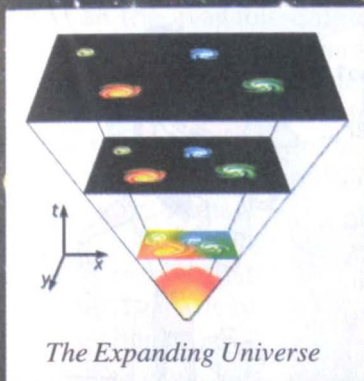
Newton



Kepler

Who were the great scientists who developed modern optics?

In the 17th century, Kepler was one of the first scientists to explore modern optics. He had many firsts to his name—he was the first to try and explain the behaviour of light, the first to explain the process of vision, the first to use a pin hole camera, the first to formulate a geometric theory of lenses, the first to develop eyeglasses for both near and far sightedness, and the first to explain why both eyes are needed to perceive depth! Another great scientist in this field was William Snellius, who put forward Snell's Laws of Refraction. Newton's contribution to this field was his theory of colours, while the theory of light was developed by Christian Huygens around the same time.



How did science grow after the 17th century?

Before the 17th century began, science and scientists were not truly recognized. In fact, even great scientists like Newton were called 'natural philosophers'. The latter half of the 17th century was a period of peace and prosperity. Newly invented machines became part of the daily life of 17th century folk.

The 18th and 19th century also saw great progress being made in science. 19th century achievements in science included the invention of the internal combustion engine, the telephone, telegraph and railroads. The 20th and 21st century has seen many



Electromagnetism

The relationship between electricity and magnetism was first established by Hans Christian Oersted, a Danish physicist. He noticed that when a wire carrying electric current was placed near a magnetic needle, the needle swung at right angles to the wire. In 1820, this led to the birth of a new branch of science - Electromagnetism.

mind-boggling developments in science, including plate tectonics, genetic engineering, space probes, nanotechnology, Big Bang theory, electronic computers, nuclear weapons, artificial intelligence, and many other astounding products of the human mind.

I'm a scientist, not a natural philosopher...



Edison's Bulb

Why has electricity been one of the greatest discoveries of science?

Electricity is one of the most powerful of forces, and the discovery that we could harness electrical energy led to many great inventions that have revolutionized our lives. It was William Gilbert who coined the word 'electricity' in the 17th century. A little later, Otto van Guericke built the first electric generating machine which popularized experiments with electricity. In 1729, Stephen Gray, an English scientist, discovered conductivity, and in 1765, Joseph Priestley com-



James Joule

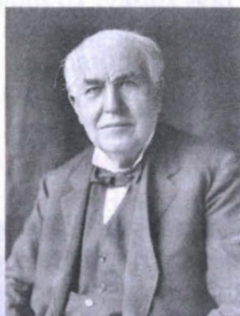
Joule's Law

In 1840, Joule established that the heat generated (Q) in a wire by an electric current (I) for a time (t) was proportional to the resistance (R) and the square of the current. It is expressed as: $Q = I^2 R t$. This is known as Joule's Law.



piled all the available data on electricity. Priestley's observations were transformed into a law known as Coulomb's Law by Charles Coulomb. The invention of the voltaic battery by Alessandro Volta in the 19th century was another important milestone.

In 1821, Michael Faraday built an electric motor that converted electricity into mechanical motion. This was followed by a series of important inventions and discoveries, but it was Thomas Edison who invented the means of generating this force and distributing it. This made electricity a part of our everyday life.



Thomas Edison

Benjamin Franklin



Static Electricity

All physical objects are made up of atoms. In an atom are protons, electrons, and neutrons. The protons are positively charged, the electrons are negatively charged, and the neutrons are neutral. Static electricity is the result of an imbalance between negative and positive charges in an object. When you comb your hair, or rub your feet on a carpet, this causes an imbalance which causes electrons to be discharged. When this happens, you feel a mild shock which is static electricity.



Unknown Rays

Wilhelm Conrad Roentgen, a German professor of physics, was the first person to discover electromagnetic radiation in a wavelength range commonly known as X-rays today. To highlight the unknown nature of these rays, he called them X-rays. He was honoured with the first Nobel Prize in Physics in 1901 for this discovery.



Roentgen.

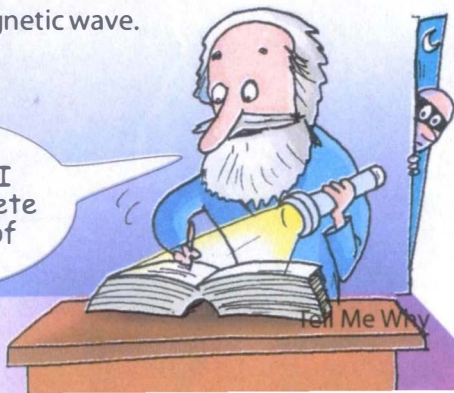
Why James Clerk Maxwell considered a hero in physics?

James Clerk Maxwell was a Scottish theoretical physicist and mathematician. He is best known for his work on light and electromagnetic waves. Maxwell showed that oscillating charges produced waves in an electromagnetic field, and that these waves had the same speed as light. He also predicted the existence of other forms of electromagnetic radiation, such as radio waves. He produced a set of equations, known as 'Maxwell's Equations' that explain the properties of magnetic and electric fields, and help to show that light is an electromagnetic wave.



*James Clerk
Maxwell*

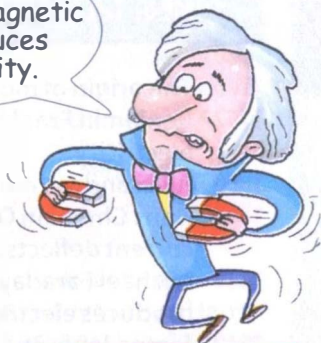
Don't disturb me! I have to complete this theory of light.



Why is electromagnetic technology so useful to the world today?

Electromagnetic technology began with Faraday's discovery that a changing magnetic field induces an electric current. His findings showed that mechanical energy can be converted to electric energy. It provided the foundation for electric power generation, leading directly to the invention of the dynamo, and the electric motor. Faraday's finding also proved crucial for lighting and heating systems. In 1844, Samuel Morse used this technology to send a coded message – and this led to the invention of the telegraph. Edison invented an incandescent light bulb in 1879, using this technology, and Alexander Graham Bell used it in the telephone. Marconi employed radio waves to send a wireless message across the Atlantic in 1901, and this led to broadcast radio transmission. Radar systems, televisions and computers, all depend on this technology.

Oh!
Changing magnetic
field induces
electricity.



Sub Atomic World

J.J Thomson discovered the electron, and opened the door to the subatomic world. This set the stage for Max Planck's Quantum Theory. The model for the hydrogen atom is attributed to Ernest Rutherford, who was Thomson's student.

Maglev Train

This train has no wheels, and no engine, but can move at speeds up to 480 kmph or more. Magnetic levitation (maglev) trains float on a cushion of air above the rail. The electromagnets attached to the train and rail levitate the train, and propel it forward.

The Story of Science



SOME OF THE IMPORTANT DISCOVERIES THROUGH THE YEARS

- 1700's** The origin of modern scientific disciplines.
- 1752** Benjamin Franklin proposes the single fluid theory of electricity.
- 1800** Alessandro Volta invents chemical batteries and voltage.
- 1820** Hans Christian Orsted notices that electric current deflects a magnetized needle.
- 1821** Michael Faraday shows that changing magnetic field produces electricity.
- 1840** James Joule and Hermann von Helmholtz proposes that electricity is a form of energy.
- 1873** James Maxwell presents equations of electromagnetism.
- 1887** Heinrich Hertz transmits radio waves.
- 1895** Wilhelm Roentgen discovers X-rays.
- 1897** J.J. Thomson discovers the electron.
- 1898** Pierre and Marie Curie separate radioactive elements.
- 1900** Max Planck invents the quantum theory of radiation.
- 1905** Albert Einstein formulate the theory of Relativity.
- 1913** Niels Bohr applies Planck's theory to the atomic structure.
- 1923** Erwin Schrodinger's wave equation.
- 1927** Max Born and Werner Heisenberg formulate matrix mechanics.
- 1949** Richard Feynman, Julian Schwinger, and Shin'ichiro Tomonaga formulate quantum electrodynamics.
- 1967** Steven Weinberg, Sheldon Glashow and Abdus Salam's formulate unified theory of electromagnetic and weak forces.
- 1964** Superfluid helium-3 discovered by David Lee, Douglas Osheroff, and Robert Richardson.
- 1986** Discovery of high-temperature superconductivity by Karl Muller and J. Bednorz.

What is Thermodynamics?

In the 18th and 19th centuries, important advances were made in the concept of energy, and in the discovery of the laws of thermodynamics. The study of thermodynamics is the study of the amount of energy moving in and out of systems. There are many different forms of energy. One form of energy can be transferred to another form. The laws of thermodynamics govern how and why energy is transferred. Galileo and Newton, the French engineer Sadi Carnot, the German scientist Rudolf Clausius, the Austrian physicist Ludwig Boltzman, Lord Kelvin and Walther Nernst all made significant contributions to the study of thermodynamics.

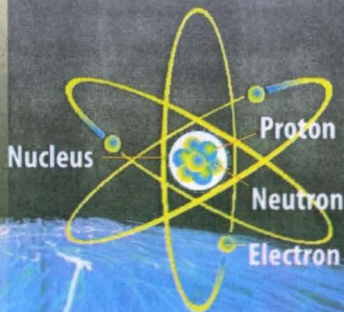


Max Planck



Atom Model

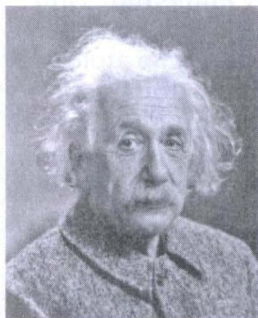
Radioactivity was discovered by Henry Becquerel in 1896. It was Rutherford who developed a nuclear model of the atom in 1911. In this model, the atom has a dense, positively charged nucleus, in which all the mass is concentrated, around which negatively-charged electrons circulate.



Planck's Constant



Quantum theory evolved as a new branch of theoretical physics during the first few decades of the 20th century. It is an attempt to understand the fundamental properties of matter. Certain radiation effects could neither be explained by classical mechanics, nor by the theory of electromagnetism. Max Planck



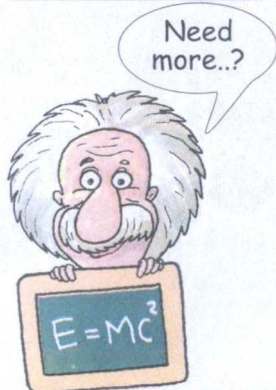
Albert Einstein

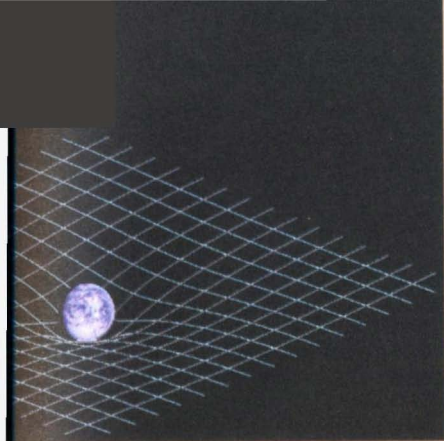
Why is Einstein considered one of the greatest among scientists?

Albert Einstein was one of the greatest scientists of all time. Einstein's special theory of relativity assumed that light travelled through space in the form of photons. He also asserted that the speed of light in a vacuum does not vary, and is independent of the speed of its source. His equations showed that mass increases with velocity, and that time is foreshortened by velocity. Until the end of his life, Einstein sought a unified field theory, whereby the phenomena of gravitation and electromagnetism could be derived from one set of equations. The papers that he published changed Man's view of the Universe, and led to the final acceptance of the atomic structure of matter.

Why is Einstein's Theory of Relativity important?

Albert Einstein published his famous General Theory of Relativity in 1915, which





developed a new formula which stated that energy is always emitted or absorbed in discrete units, which he called quanta. Planck developed his quantum theory further, and derived a universal constant, which came to be known as Planck's constant.

*Projection of a Space Time
Curvature Described in General
Relativity*

continues and expands the Special Theory. The main points of the theory are that, the maximum velocity attainable in the Universe is that of light, and that objects appear to contract in the direction of motion and vice versa.

Another important observation is that mass and energy are equivalent, and interchangeable properties. This gave rise to the most famous formula in the world. It states that matter can be converted into energy, or ' $E = mc^2$ '. In short, Albert Einstein's theory changed our concepts of space and time.

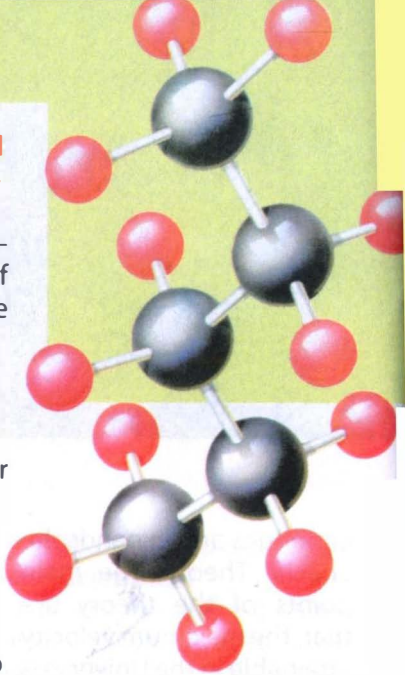
Einstein's Home

The Story of Science

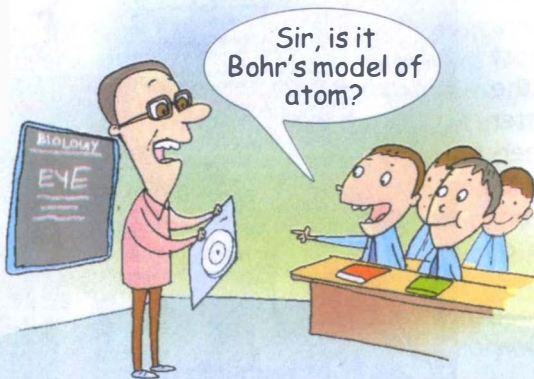


Why is Niels Bohr considered to be the father of atomic structure?

Niels Bohr was a Danish physicist whose investigations of atomic structure earned him the 1922 Nobel Prize for physics. Bohr's work helped solve the problems classical physics could not explain about the nuclear model of the atoms. Bohr developed his own theory about the structure of the atom. He described an atom as a miniature solar system, with electrons revolving around the heavy nucleus. According to Bohr, each electron has a fixed amount of energy that corresponds to its fixed orbit, and so, different electrons spin in different orbits around the nucleus.



Ball and Stick Representation of a Molecule



Niels Bohr



Birth of Modern Physics

By the end of the 19th century, it was felt that physics had evolved to a point where all the important laws of physics had been discovered. However, the beginning of the 20th century witnessed a major revolution in the

world of physics which ushered in the era of modern physics.

Why is quantum mechanics an advanced concept?

Quantum physics is a branch of physics that works with the activities going on inside of atoms. In the early 1900's, scientists were beginning to examine the inside of atoms. Niels Bohr had put forward the theory that in every atom, there is a nucleus, and there are rings or orbits of energy around the nucleus. The length of each orbit was related to a wavelength of electromagnetic radiation (EM). Scientists now say that electrons behave like waves, and fill areas of the atom. Sci-



*Proton (Red)
Neutron (Black) and
Path of Electrons (Blue)*

entists also discovered that EM radiation not only moves like a wave, but has packs of energy known as quanta. The term 'quantum mechanics' was given to this branch of physics by Max Born in 1924.

He is searching for the sub atomic particle in his break fast.



What do you know of subatomic particles?

Subatomic particles are particles that are smaller than atoms. Physicists have discovered hundreds of particles smaller than the three best known subatomic particles that make up an atom- protons, neutrons, and electrons. Most subatomic particles exist for only fractions -less than a billionth- of a second, and some particles combine to form more stable composite particles.



Super Star Neutrino

A neutrino is a sub atomic particle that is believed to be mass-less, or to have a very small mass. A neutrino is very similar to the electron, except that it does not carry an electrical charge.

Fermions are subatomic particles that make known matter and anti-matter. Leptons are elementary particles that do not participate in holding the nucleus together. Quarks, on the other hand, are elementary particles that do participate in holding the nucleus together. Then there is anti-matter, which consists of counter-particles of quarks and leptons. Hadrons are composite particles like the proton and neutron, while bosons are particles that carry four types of forces.



Large Hadron Collider

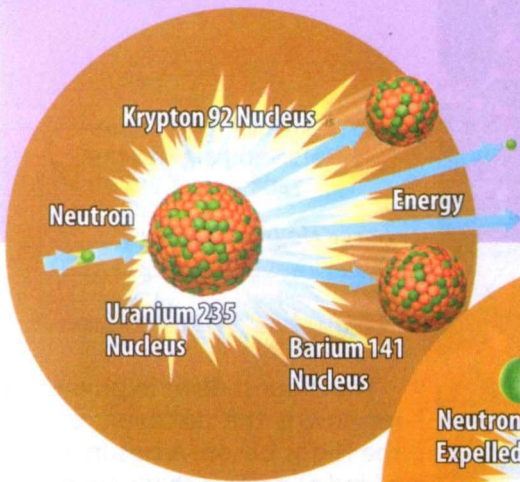
Why has Higgs boson become very important?

The biggest news in physics now is the discovery of the Higgs boson. A boson is a kind of particle that's even smaller than an atom. But it took nearly 50 years to find out that it really exists.

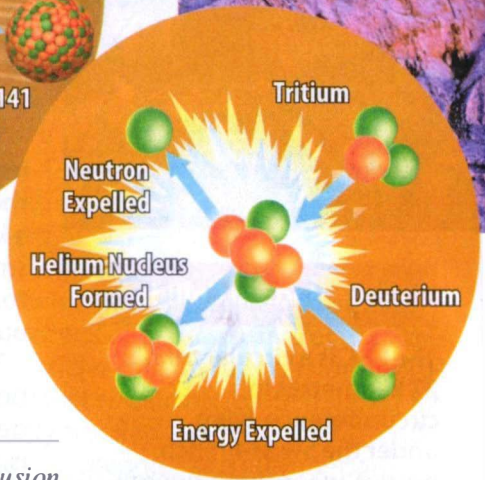
To understand what Higgs boson is, you must first understand what mass is. Mass is, quite simply, a measure of how much stuff an object - a particle, a molecule, or a box - contains. If not for mass, all of the fundamental particles that make up atoms would whiz around at the speed of light, and the Universe as we know it, could not have clumped up into matter. The Higgs mechanism proposes that there is a field of bosons in the Universe which is now called the Higgs field. When particles interact with the field, and with the Higgs bosons in it, mass is formed.

Large Hadron Collider

The LHC is a circular tunnel, 27 kilometres in circumference, lying under the Swiss-French border, where high-energy protons in two counter-rotating beams collide. It was built by the European Organization for Nuclear Research or CERN, to test the predictions of different theory of particle physics. On July 4th, 2012, CERN announced that they had discovered a new subatomic particle greatly resembling the Higgs boson. It is one of the greatest scientific discoveries of all time.



Nuclear Fission



Nuclear Fusion

What is condensed matter physics?

Condensed matter physics deals with the thermal, elastic, electrical, magnetic and optical properties of matter in a condensed state. It is a sub-branch of quantum physics and statistical mechanics.

Condensed-matter physics grew at an explosive rate during the second half of the 20th century, and it has scored numerous important scientific and technical achievements.

Tell Me Why

I will spilt this atom, and create a nuclear fission.





A Uranium Mine

Why is nuclear fission a major milestone in physics?

In nuclear fission, atoms of heavy elements, such as uranium or plutonium, split, to form atoms of lighter elements. When atoms undergo fission, energy is released.

The history of nuclear fission begins with the discovery of the neutron by James Chadwick in 1932. Enrico Fermi in Italy started studying the nuclear reactions produced when different elements were bombarded with neutrons. In 1939, Hahn in Germany announced that he had obtained nuclear fission. In 1939, Frederic Joliot-Curie, Hans von Halban, and Lew Kowarski found that several neutrons were emitted in the fission of uranium-235, and this discovery led to the possibility of a self-sustaining chain reaction. Nuclear power plants produce energy by nuclear fission reactions of radioactive elements like uranium.



Big Bang

Most scientists believe the Universe began in a Big Bang about 14 billion years ago. At that time, the entire Universe was inside a bubble that was thousands of times smaller than a pinhead. Then it suddenly exploded. The Universe that we know was born! In a fraction of a second, the Universe grew from smaller than a single atom, to bigger than a galaxy! And it kept on growing at a fantastic rate.



*A High Temperature
Super Conductor
Levitating above a
Magnet*

Why is superconductivity fascinating?

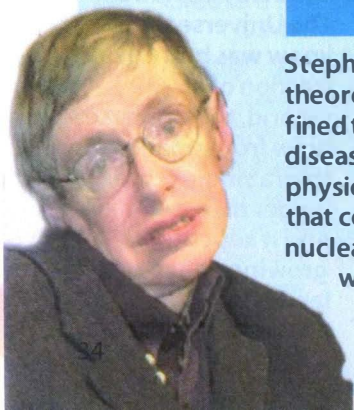
Superconductivity is the complete disappearance of electrical resistance in various solids when they are cooled below a temperature called the transition temperature. The transition temperature varies for different materials, but is generally below -253°C . Superconductivity was discovered in 1911 by the Dutch physicist Heike Kamerlingh Onnes. In 1986, a new class of high-temperature superconductors was discovered by Karl Alex Muller and J Georg Bednorz. These superconductors hold great promise, as they can be used for many practical purposes.



*Heike Kamerlingh
Onnes*

Amazing Man

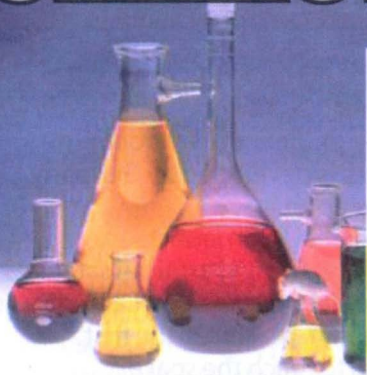
Stephen William Hawking is one of the greatest theoretical physicists of the 21st century. Confined to a wheelchair because of a neurological disease, Stephen Hawking is among the many physicists working on a 'Theory of Everything' that covers gravity, electromagnetic forces, and nuclear and weak interactions. Such a theory would explain the workings of everything in the Universe.





- 1926:** The first liquid-fuelled rocket is launched by Robert H. Goddard.
- 1944:** V2, the pioneer of all modern rockets is developed by Germany, as a weapon.
- 1957:** The Soviet Union launch Sputnik 1, the first artificial satellite.
- 1957:** The Soviets put the dog Laika on a spacecraft, making it the first animal to reach the space.
- 1958:** The first US artificial satellite, Explorer 1 is launched.
- 1961:** The Soviet Cosmonaut Yuri Gagarin becomes the first man to reach the space.
- 1963:** The Soviet Cosmonaut Valentina Treshkova becomes the first woman to reach the space.
- 1969:** US astronauts Neil Armstrong and Edwin Aldrin becomes the first men to step on the Moon.
- 1971:** The first space station Salyut 1 is launched by the Soviet Union.
- 1975:** India launches its first satellite Aryabhata.
- 1981:** US launch First Space Shuttle Columbia.
- 2008:** India launches Chandrayan-I to explore the Moon.
- 2012:** US robot rover Curiosity lands on Mars.

CHEMISTRY



The word 'chemistry' comes from the Greek word 'chemeia,' which referred to the art of metal – making in the 4th century.

How did chemistry originate?

The origin of chemistry goes back as far back as pre-historic times. Fire was known to the ancestors of humans about a million years ago. After Man discovered fire, he began to use it to harden pottery, and extract metal from ore.

In the 5th century BC, Empedocles, a Greek philosopher, said that all matter was made of four elements. They were fire, air, water, and earth. Between 300 BC and 300 AD, alchemy became very popular. Alchemy was the practice of attempting to turn base metals into gold.

Why were alchemists considered to be the first chemists?

Alchemists believed there were four spirits - mercury, sulfur, arsenic, and sal ammoniac - and six bodies - gold, silver, copper, tin, lead, and





Robert Boyle

Robert Boyle was an English philosopher, naturalist, and chemist. He rejected Aristotle's theory of matter, and presented the hypothesis that corpuscles, or atoms, were the finest division of matter.

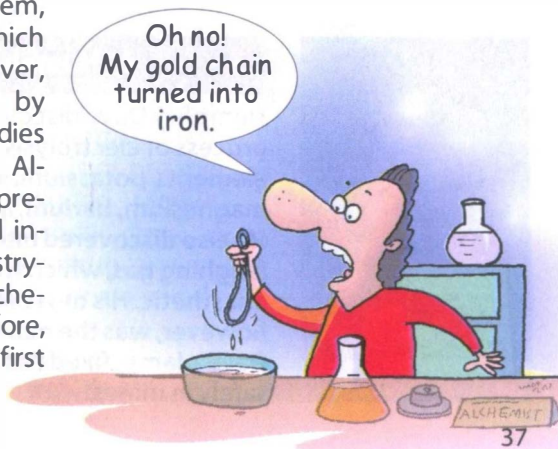


Robert Boyle

How did modern chemistry begin?

Modern chemistry began to emerge when Robert Boyle made a clear distinction between chemistry and alchemy in 1660. German chemists Johann Becher and Georg Ernst Stahl laid the foundation for the modern theory of combustion. The English chemist Joseph Priestley discovered in 1774, that oxygen is essential to the burning process. Henry Cavendish identified hydrogen, and in 1783, Lavoisier developed the theory of conservation of mass.

iron. According to them, the purest bodies, which were gold and silver, could be obtained by treating the other bodies with the four spirits. Alchemy was an early precursor to science, and included many chemistry-related processes. Alchemists were therefore, considered to be the first chemists.

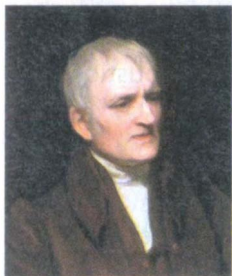




Atoms could not be created, but a cup of tea we can make!

Why is Dalton's Atomic Theory a milestone in chemistry?

In 1805, John Dalton, an English schoolteacher, developed the atomic theory. He claimed that all elements were made of atoms, and that atoms of the same elements were identical. Atoms could not be



John Dalton

created, divided, or destroyed in a chemical process. However, they could combine with atoms of other elements to form a chemical compound. Later, Jons Jacob Berzelius determined the atomic weight of 40 elements. Joseph-Louis Gay-Lussac, a Frenchman, established that hydrogen and oxygen combine by volume in the ratio 2:1 to form water. It was Dalton's work therefore, that laid the foundation for what is called modern chemistry today.



Humphry Davy

Humphry Davy

Humphry Davy discovered the process of electrolysis, and isolated the elements potassium, sodium, calcium, magnesium, barium, and strontium. He also discovered nitrous oxide, or laughing gas, which was used as the first anesthetic. His most important invention however, was the miner's safety helmet. Davy's lamp, fixed to a helmet, could burn safely in mines.

Purple Discovery

Do you know that iodine was discovered by accident? It happened when a French chemist, Bernard Courtois noticed purple vapours rising from kelp ashes that he had acidified with sulfuric acid, and heated. The vapours condensed on a cold surface to form shiny dark crystals. These crystals were later proved to be an element that was called iodine, after the Greek word for violet, *iode*.



Why is it said that Friedrich Wohler started a new era in chemistry?

Chemicals are split up into organic chemicals and inorganic chemicals. It was earlier believed that organic chemicals were found only in living things. In 1828, Friedrich Wohler, a German scientist, accidentally synthesized urea, an organic compound known to occur in living things, from an inorganic substance, ammonium cyanate. This opened a new era of research in chemistry. By the end of the 19th century, scientists were able to synthesize hundreds of organic compounds. These included mauve, magenta, and other synthetic dyes, as well as the widely used drug aspirin. Wohler's works on chemistry are widely used as texts today.



Iodine



Friedrich Wohler



Carbon the Great

Living things are made up of carbon compounds, and so, organic chemistry is dedicated to its study. Organic compounds can be divided into families such as proteins, fats, and sugars. Carbon is different from all other elements because it has the unique ability to form very stable bonds with itself. So, there are long chains that contain hundreds of thousands of carbon atoms.



Beam of Electrons Deflected in a Circle by a Magnetic field.



J.J. Thomson

How was the electron discovered?

Electrons are particles that surround the nucleus of an atom. Electrons have negative charges. They were discovered in 1897 by J.J. Thomson. Thomson's discovery of the electron began in 1895, with a series of experiments. He conducted experiments with beams of negative particles, and he discovered that these beams or rays consisted of



J. J. Berzelius

J.J. Berzelius was a doctor who developed a chemical notation in which elements were represented by letters, typically the first letters of their chemical notation. Thus, oxygen was O, and copper was Cu. He was the first person to make the distinction between organic and inorganic compounds. Berzelius coined many new terms, and identified many new elements too.



J. J. Berzelius



Rutherford

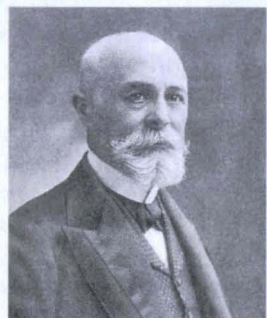
Why was the discovery of proton and the nucleus very important?

In the early 1900's, it was understood that atoms contain electrons, and that electrons have a negative charge. In 1910, a physicist from New Zealand, Ernest Rutherford carried out a series of experiments which suggested that most of the atom must be empty space. The atom's positive charge, Rutherford proposed, was concentrated in the nucleus, which is a dense central core within the atom. The positively charged particles in the nucleus are called protons, and each proton carries the same quantity of charge as an electron. The proton however, has a mass about 1,840 times the mass of the electron. The discovery of both protons and neutrons are important milestones in the development of atomic theory, which allowed for a greater understanding of how molecules bond and work.

lightweight particles with a negative charge. These particles were electrons. The device J.J. Thomson used for these investigations was the cathode ray tube, the forerunner of the television tube.

Why was the discovery of radioactivity said to be accidental?

In 1896, Henri Becquerel was using naturally fluorescent minerals to study the properties of X-rays which had been discovered in 1895 by Wilhelm Roentgen. He exposed potassium uranyl sulfate to sunlight, and then placed it on photographic plates wrapped in black paper, thinking that the uranium absorbed the sun's energy, and then emitted it as x-rays. His experiment failed, because the sky was overcast, and there was no sunlight. For some reason, Becquerel decided to develop his photographic plates anyway. To his surprise, the images were strong and clear, proving that the uranium emitted rays spontaneously without the help of any external source like the sun. Becquerel had discovered radioactivity by accident, and now an element that spontaneously emits radiation is said to be radioactive. Radioactive substances such as uranium produce three types of rays or particles when they decay, or break down- alpha, beta, and gamma rays.



Henry Becquerel



Tell Me Why



Discovery from a Dream

The idea that carbon atoms join together to form a ring was put forward in 1865, when a German chemist, Friedrich August Kekule von Stradonitz suggested a ring structure for benzene, an organic compound. He got this idea after he dreamt of a snake biting its tail!



Kekule

Avegado Number

Avogadro, an Italian, was the first to publish in 1811 the idea that elements could exist as molecules. The word 'molecule' was a Latin word that he adopted for his hypothesis, explaining why mixing a volume of hydrogen gas with an equal volume of chlorine gas does not result in a doubling in the volume of gas. The hypothesis states that equal volumes of ideal gases, at the same temperature and pressure, contained an equal number of molecules.



Avogadro



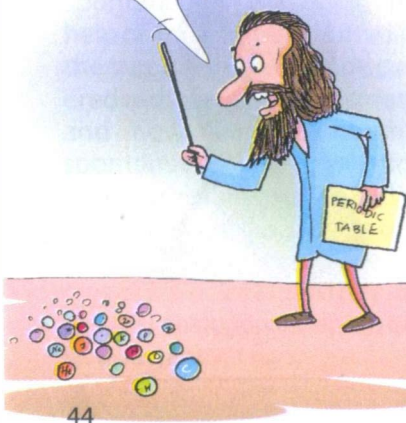
James Chadwick

The Neutron

In 1932, James Chadwick proved that the atomic nucleus contained a neutral particle which had been proposed more than a decade earlier by Ernest Rutherford.

Periodic Table of the Elements

All of you
stand in a
queue...



Why is Mendeleev's periodic table so important?

People have known about elements like carbon and gold since ancient times. In the late 1860's, Dmitri Mendeleev began working on his great achievement- the periodic table of the elements. By arranging all of the 63 elements then known by their atomic weights, he managed to organize them into groups possessing similar properties. First, he put elements into their correct places in

Tell Me Why

Why has the invention of artificial fibres and dyes changed the world?

Until the 19th century, the only fibres that were available for weaving fabrics were natural



Rayon

This rayon might help save our lives!



ones- linen, wool, silk, and cotton. The first man-made fibre was produced about 1855, and it was primarily used as a substitution for silk. It went by the name viscose and was later renamed rayon. Rayon is technically not artificial, nor is it natural. It is made artificially from a natural substance- from wood cellulose. Nylon is the first truly man-made artificial fibre, as it is made entirely of petrochemicals.

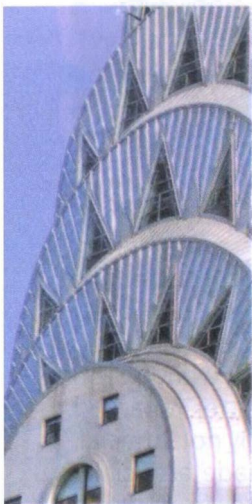
the table. The greatness of Mendeleev was that not only did he leave spaces for elements that were not yet discovered, but he predicted properties of five of these elements and their compounds!



Robert Bunsen

Spectroscope

The spectroscope is used in chemistry to identify and measure various chemical substances. The credit for its discovery goes to Robert Bunsen, who is better known for creating the Bunsen burner.



*Stainless
Steel Cladding*

Why are petrochemicals, fibreglass, and rubber considered major developments in chemistry?

Improvements in petroleum refining techniques led to the emergence of petrochemicals and plastics. One of the most important results of the new processes that were developed was the discovery that petrol could be made by refining petroleum, and petrol is essential for life today. Fibreglass, a form of synthetic glass, was first developed by Games Slayter, an American inventor in the 1930's. When natural rubber became scarce during World War I, synthetic rubber was invented by chemists. We use thousands of rubber products with varying degrees of hardness in our daily lives. In short, the 20th century saw the development of several other synthetic materials that proved to be immensely useful for humankind - thanks to chemistry.

Developing Chemistry

The 19th century saw giant strides being made in every walk of life. The Industrial Revolution, improved transport and communication, while developments in medicine and agriculture improved the quality of life - and chemistry played a major role in this transformation.



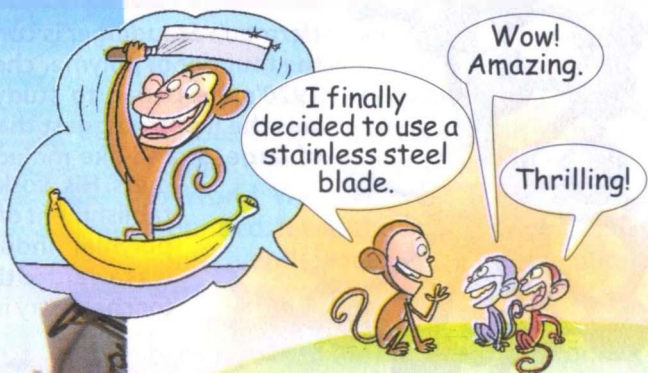
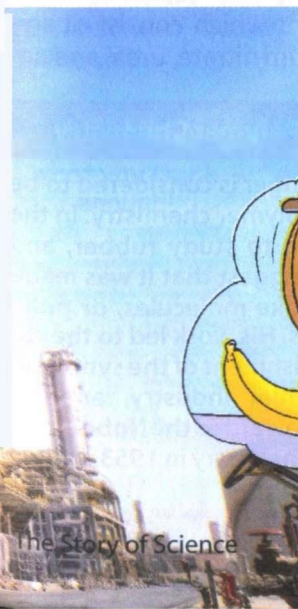


Steel Rods

Why was the invention of stainless steel a milestone in economic development?

Steel is an alloy of carbon and iron. It is extremely strong, and its properties make it especially useful in producing weapons. In 1872, the English company Messrs Woods and Clark patented an alloy of iron, chromium, and tungsten that was resistant to acid and weather. This could be considered the first patent for what came to be known as stainless steel. However, it was only in 1913 that Harry Brearley created the first-ever stainless steel. Stainless steel's resistance to corrosion and staining, low maintenance, and attractive appearance, make it an ideal material for many applications. There are over 150 grades of stainless steel, of which fifteen are most commonly used. Today, everything from buildings to kitchen utensils use stainless steel.

Petrochemical Plant





Fritz Haber



Hermann Staudinger

How did nitric acid and ammonia revolutionize agriculture?

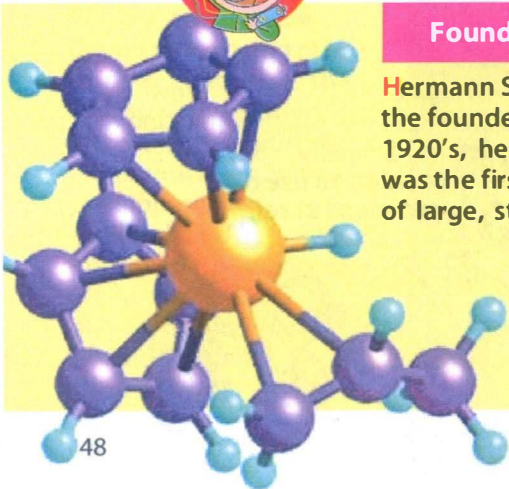
The important nutrients essential for plant growth are often lacking in the soil, which creates the need for fertilizers. The big breakthrough in the field of artificial fertilizers

came in 1908 when Friedrich Wilhelm Ostwald invented the process to manufacture nitric acid, which can be used as a base for fertilizers. In 1908, Fritz Haber, developed a process to make ammonia gas from the nitrogen in the air. Ammonia is used in the production of liquid fertilizer solutions which consist of ammonia, ammonium nitrate, urea, and aq-



Founder of Polymer Chemistry

Hermann Staudinger is considered to be the founder of polymer chemistry. In the 1920's, he began to study rubber, and was the first to suggest that it was made of large, strand-like molecules, or polymers. His work led to the establishment of the synthetic polymer industry, and he was awarded the Nobel Prize for chemistry in 1953.

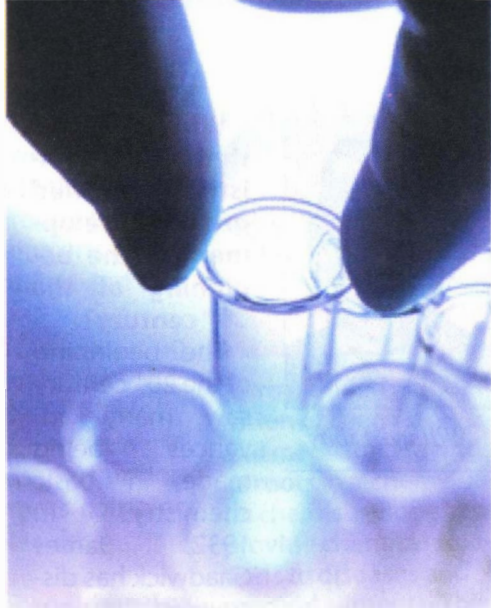


Allotropes of Carbon

The allotropes of carbon are the different molecular configurations that pure carbon can take. Carbon is a remarkably versatile element. Allotropes of carbon can be as hard as diamonds, or as soft as graphite.

ua ammonia. Artificial fertilizers boosted agricultural productivity, because the nutrients they provided could be absorbed quickly by the soil.

You can use what you think enough!



Why is the development of the pharmaceutical industry so significant?

As the horizons of chemistry expanded, new industries that were related to chemistry grew too. In 1928, Alexander Fleming, a biochemist, discovered penicillin quite by accident. This discovery made a stupendous difference to the world.

Further experiments revealed that the fungus, *Penicillium notatum*, could kill many kinds of bacteria and could be administered to laboratory animals without danger. Penicillin was used extensively in World War I to treat the sick and wounded. It was the first antibiotic, and subsequently, many other antibiotics were discovered too. As a result, the pharmaceutical industry boomed, and became one of the biggest in the world.



Willard Libby

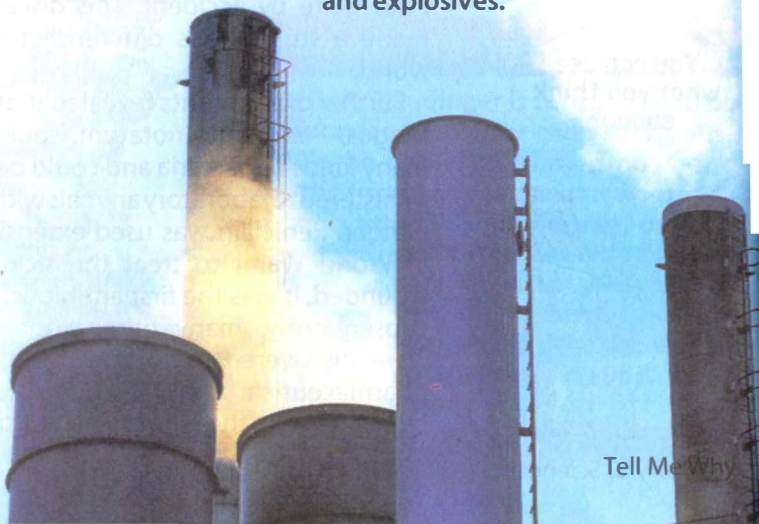
Why is it said that basic chemistry showed great development in the beginning of the 20th century?

The beginning of the 20th century saw many advances being made in basic chemistry. In 1932, James Chadwick has discovered the neu-



Industrial Chemistry

Industrial Chemistry deals with the production of inorganic chemicals, organic chemicals, petrochemicals, agrochemicals, and explosives.



tron, and this led to intense research in this field. Many scientists were engaged in studying the reactions that occurred when the nuclei of different elements were bombarded with neutrons. Many new elements were identified and created.

The technique of radiocarbon dating was developed during this time by William Libby. It is used to date artifacts by applying radioactivity. Progress in quantum mechanics helped us understand how individual atoms combine to form chemicals or molecules.

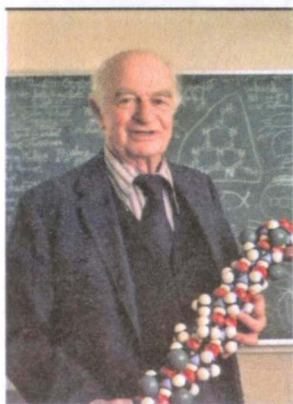
Why is Linus Pauling considered to be an important chemist of the early 20th century?

Linus Pauling was a scientist, and a founding father of molecular biology. He gave a big boost to modern theoretical organic chemistry. He also determined the role of electrons in the formation of molecules. Pauling proposed the idea that vitamin C could help prevent cancer. The work of Pauling on the chemical bond culminated in his famous textbook, 'The Nature of the Chemical Bond', which was published in 1939. It is considered by many scientists as the most influential work in chemistry. Pauling won the Nobel Prize for Chemistry in 1954. He was also awarded the Nobel Peace Prize in 1962, for his efforts to stop atomic bomb research.



Latrochemistry

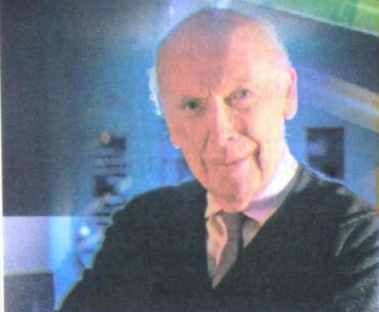
Latrochemistry was a fusion of chemistry and medicine. Having its roots in alchemy, latrochemistry sought to provide chemical solutions to diseases and medical ailments. This area of science has fallen out of use since the rise of modern medical practices.



Linus Pauling

Frederick Sanger and DNA

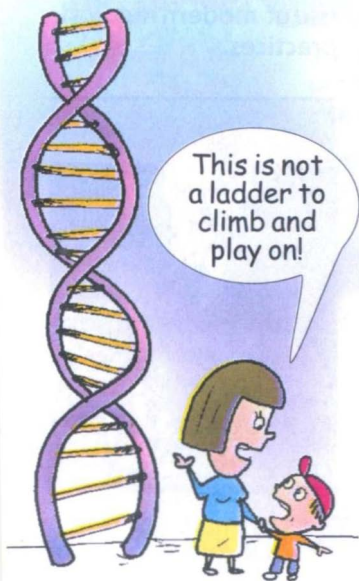
Frederick Sanger proved that proteins have a definite chemical composition. He also developed a method for sequencing the DNA molecule, and determined the amino acid structure of the hormone insulin in 1955.



James Watson

Why are James Watson and Francis Crick associated with DNA?

DNA is the molecule that is the basis for heredity. It contains the patterns for constructing proteins in the body, including the various enzymes. A new understanding of heredity and hereditary disease was possible once it was determined that DNA consists of two chains twisted around each other, or double helixes. Modern biotechnology also has its basis in the structural knowledge of DNA. James Watson, Francis Crick, Maurice Wilkins, and Rosalind Franklin were four scientists who worked to unravel the mysteries of DNA. Franklin died of cancer at the young age of 37. In 1962, James Watson, Francis Crick and Maurice Wilkins jointly received the Nobel Prize for their 1953 determination of the structure of DNA.

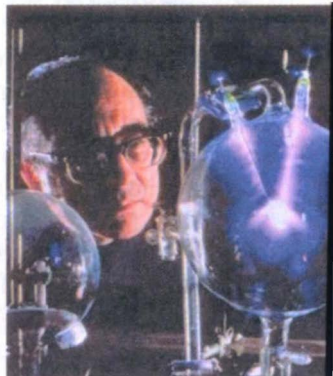


What do we know about inorganic chemistry?

Inorganic chemistry is the study of all the elements and their compounds with the exception of carbon and its compounds, which fall under the category of organic chemistry. At the turn of the 20th century, experiments by scientists Urey and Miller proved the hypothesis that life originated on the primordial Earth from inorganic molecules. Hans Krebs discovered the citric acid cycle that has come to be known as Krebs' Cycle. The Krebs' Cycle helps us to understand how living beings are able to convert food into energy and waste products. The detailed chemical process underlying photosynthesis was understood only in the second half of the 20th century. Inorganic chemistry has now become a science concerning inorganic materials based primarily on data about the structure of compounds on the atomic and molecular levels.



Hans Krebs



Stanley Miller



NMR Spectroscopy

Among the most important tools for analytical chemistry is the Nuclear Magnetic Resonance or NMR spectroscope. It is extensively used to determine the structure of large biological molecules.

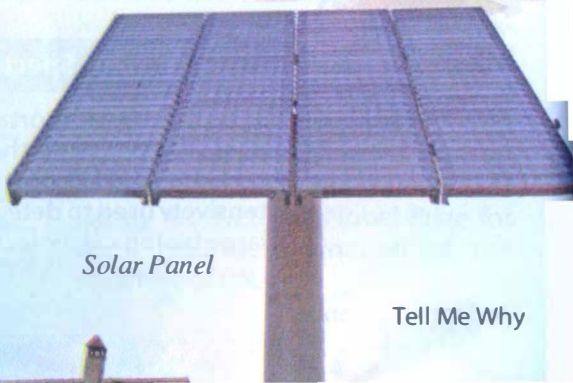
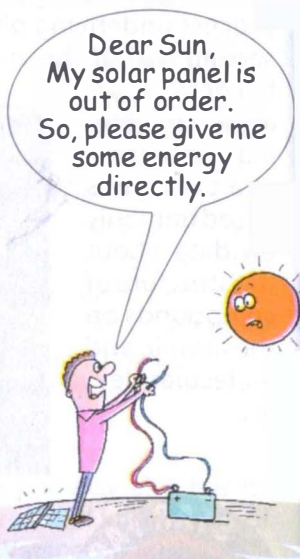
Conductive Polymers

Polymers are molecules that form long, repetitive chains. Plastics are among the best known polymers. Conductive polymers are polymers that can conduct electricity. Conductive polymers can be combined with conventional plastics to create a product that possesses the qualities of both the materials. Conductive polymers were discovered in 1977 by A.J. Heeger, MacDiarmid, and H. Shirakawa.

Why is chemistry useful in the field of energy?

Solar power, or the technique of converting the energy received from the Sun into useful and usable energy has become increasingly important, and chemistry plays a role in producing solar power. A solar cell is really only a converter that takes the light of the Sun, and turns it into electricity. Many of the processes that occur in chemistry are dependent on the state of the electrons floating around the outside of the nucleus- and the material of solar cells is an elaborate network of electron paths.

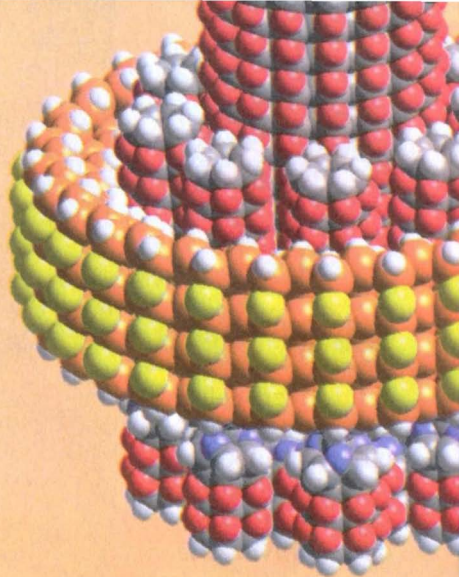
Chemistry also plays an important role in fuel cells. A fuel is any compound that has stored energy. Whether it is solar energy or other conventional forms of energy, chemistry is the key player in the process of releasing energy.



Solar Panel

Why is nanotechnology important?

Nanotechnology is the science of creating molecular-size machines that manipulate matter, one atom at a time. The name comes from nanometer—one-billionth of a metre—which is roughly the size of these tiny devices. Chemical techniques, in an area known as synthetic chemistry, are already capable of synthesizing small molecules of a variety of compounds. These are being used in the chemical industry and the pharmaceutical industry. The medical industry sees a great deal of potential in the applications of nanotechnology to diagnose, treat, and research diseases. Future applications include nanorobots and other nanoscale machines. Nanobots manipulate atoms, and can in principle, make anything from apples to airplanes.



A Nanomaterial



Carbon Nanotube

Carbon nanotubes are cylindrical carbon molecules, and have novel properties that make them potentially useful in a wide variety of applications in nanotechnology, electronics, optics, and other fields of materials science. They exhibit extraordinary strength and unique electrical properties, and are efficient conductors of heat.



Genes

Inside every cell of each living thing—plant or animal—are sets of instructions called genes. The genes provide the instructions on what is the plant or animal is, what it looks like, how it is to survive, and how it will interact with its surrounding environment.



What is green chemistry?

Chemical wastes have a significant impact on life today. Green chemistry is the invention, design, and application of chemical products and processes to reduce,

or to eliminate the use and generation of hazardous substances. For example, in order to decrease human consumption of petroleum, chemists have investigated methods for producing polymers from renewable resources such as biomass.

Green chemistry re-

Salute to green chemistry, I've decided to change my car into green.

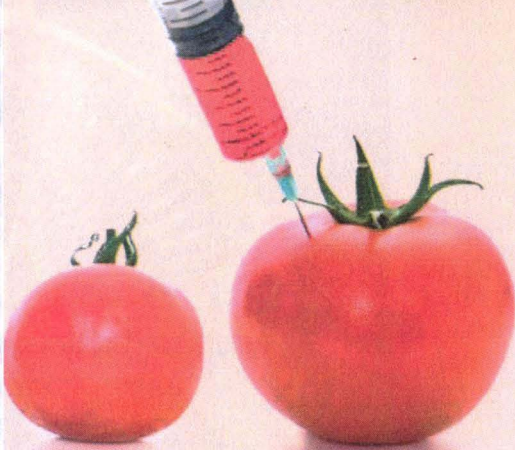


What is biotechnology?

Biotechnology is utilizing the sciences of biology, chemistry, physics, engineering, computers, and information technology to develop tools and products that hold great promise for human beings. Both traditional and modern biotechnology use living organisms to enhance crops, fuels, medical treatments, and a host of other tools that can help us. One of the areas of biotechnology is cloning. We have been cloning plants for centuries. Each time a leaf is excised from a plant and placed in soil to grow a new plant, cloning has occurred. Biotechnology can have an immense impact in the artificial increase in plant yields. In medicine, biotechnology has come a long way since the company Genentech produced human insulin using genetic engineering techniques. There is no doubt that biotechnology is the science of the future.

duces toxicity, minimizes waste, saves energy, and cuts down on the depletion of natural resources. During the 1990's many industries began to earnestly adopt green chemistry, and other sustainable practices.





G. M. Tomato

What are genetically modified crops?

Genetic modification involves altering an organism's DNA. This can be done by altering an existing section of DNA, or by adding a new gene altogether. A gene is a code that governs how we appear, and what characteristics we have.

Like animals, plants have genes too. Genes decide the colour of flowers, and how tall a plant can grow. Just as our parents pass on their characteristics to us, the characteristics of a plant will be transferred to the plant's seeds, which grow into new plants. When a scientist genetically modifies a plant, they insert a foreign gene in the plant's own genes. This might be a gene from a bacterium resistant to pesticide, for example. The result is that the plant receives the characteristics



Ethics in Genetically Modified Food

Though genetically modified crops may produce bigger fruits and flowers, and be more resistant to drought and disease, there are concerns about the safety of the food they produce, and their impact on the environment. Genetically modified crops may release

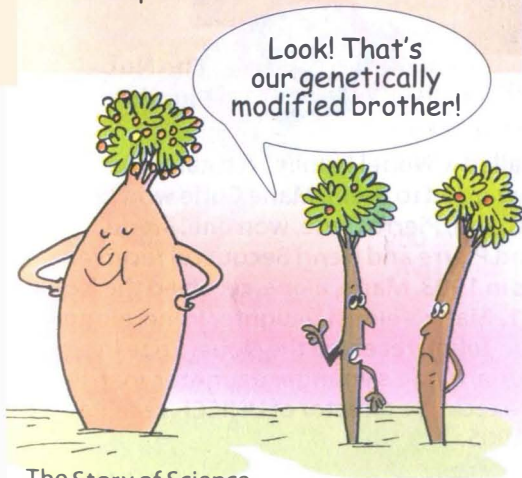
new diseases into the wild, and prove to be less hardy than natural crops in the long run. As a result, a large number of countries still do not permit the production or sale of genetically modified foods.



G.M. Plum

held within the genetic code. Consequently, the genetically modified plant also becomes able to withstand pesticides.

Apart from making crops pesticide resistant, genetic modification can actually reduce the use of pesticides and herbicides required by the crop. Genetically modified crops can also be made more resistance to drought, and some research is already taking place to accomplish this.



John Fenn

John Fenn was a scientist who developed a technique which made possible the rapid analysis of the structure of proteins, and other



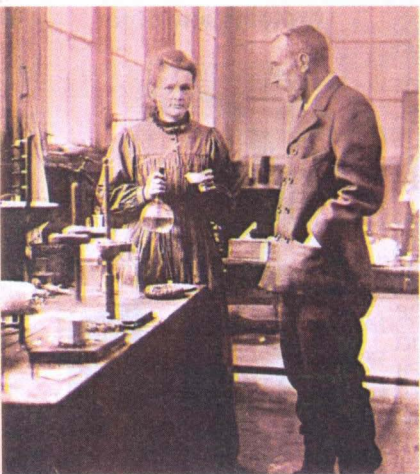
John Fenn

bimolecules through mass spectrometry. He was a Nobel Prize-winner in chemistry, and his work in the field of biomolecular technologies helped increase the speed and development of new drugs.

What advances do we expect from chemistry in the 21st century?

Chemistry in the 21st century will focus on green chemistry, genomics, and biotechnology. We can expect to see improved processes that will reduce the production of harmful wastes. Renewable energy source like solar cells will become more popular, and new materials with unusual properties will be developed.

DNA sequencing will become even quicker and more accurate, leading to its widespread use. More and more genes responsible for diseases may be identified, and therapies developed and biotechnology will usher in a revolution in agriculture too.



Marie Curie and Pierre



The Nobel Family

The Curie family can be called a 'Nobel Family'. A total of five Nobel Prizes have been awarded to them. Marie Curie won two Nobel Prizes, and her husband, Pierre Curie, won one. Marie, together with her husband Pierre and Henri Becquerel received the Nobel Prize in Physics in 1903. Marie, alone, received the Nobel Prize in Chemistry in 1911. Marie's eldest daughter Irene, along with her husband Frederic Joliot, received the Nobel Prize in Chemistry in 1935. Eve Curie, Marie's younger daughter married Henry Labouisse, who as executive director of UNICEF, received the Nobel Peace Prize in 1965.

BIOLOGY

What is the meaning of 'biology'?

Biology is the study of life processes and living organisms. The term however, is a fairly recent one, and was introduced around the 19th century. Earlier, many terms were used to describe the study of living organisms. There was natural history, which referred to the descriptive aspects of biology, and natural philosophy, and natural theology. In the 18th and 19th centuries, botany and zoology replaced natural history and natural philosophy. Today, biology encompasses not just botany and zoology, but many other fields of studies as well, including mycology and molecular biology.



The word 'biology' is made up of two Greek words- 'bio' meaning 'life' and 'logy' meaning 'study of'.

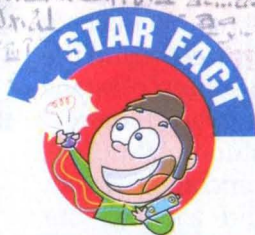
The Story of Science

Don't move,
you are my study
material today.



Why is biology a science that goes back to Ancient Mesopotamia and Egypt?

The study of natural phenomena goes back to the ancient civilizations of Mesopotamia and Egypt. The oldest Babylonian text on medicine has its origin in the first half of the second millennium BC. Papyri and artifacts found in the tombs and pyramids of the Egypt indicate that the ancient Egyptians possessed considerable medical knowledge. In fact, the mummies of ancient Egypt prove their knowledge about human anatomy, and the preservative properties of plants used for embalming. The ancient Egyptians also knew about the circulatory system and tumours. Did you know that the alluring eye makeup of the ancient Egyptian queens may have been used to help prevent, or treat eye disease by doubling as an infection-fighter? Isn't that amazing?



Egyptian Surgery

The earliest known surgery in Egypt was performed around 2750 B.C. The ancient Egyptians also knew about the importance of the pulse, and the connection between the pulse and the heart.





Chinese Surgeon

Hua Tuo was a Chinese surgeon who invented an oral anaesthetic. Using a mixture of hemp and wine, he was able to make his patients insensitive to pain. He was such an outstanding medical doctor in ancient China that he was known as a 'miraculous healer'.



Ebers Papyrus

The Ebers Papyrus is a very important scroll. It is the most comprehensive description of ancient Egyptian medicine. It contains 700 formulae and traditional remedies to cure afflictions ranging from crocodile bite to toenail pain.

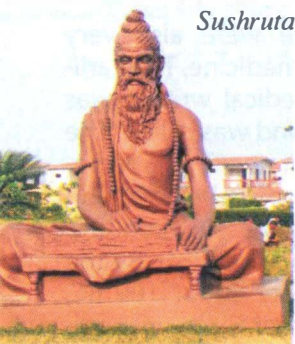
What do you know about ancient Chinese medicine?

The ancient Chinese were also very knowledgeable about medicine. The earliest known Chinese medical writing was written about 186 BC, and was called 'The Recipes for Fifty-Two Ailments.' The remedies included chanting spells, herbal medicines, lancing or cutting the skin open, and cauterization or burning the flesh. By the time of the Han Dynasty about 100 BC, China had become a major centre of medical research, and the home of some of the world's best doctors. According to the Chinese, you get sick when the two forces known as yin and yang that exist in your body are out of balance. Lifestyle choices like bad food, not exercising, stress, and your environment can knock yin and yang out of balance. Doctors used a combination of acupuncture, herbal medicines, and exercises to restore this balance. They also used many medicines made of different herbs and tree barks. By 300 AD, Ge Hong was the first doctor in the world to write about a medicine for malaria.



The Origin of Life

The ancient Greeks had many theories about the origin of life. In the 6th century BC, Thales of Miletus theorized that the world and all living things were made from water. His student Anaximander had a different view. He proposed that life arose spontaneously in mud.

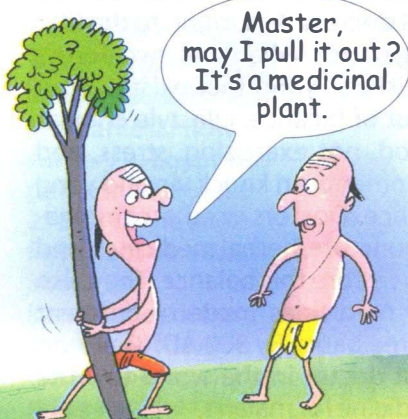


Sushruta

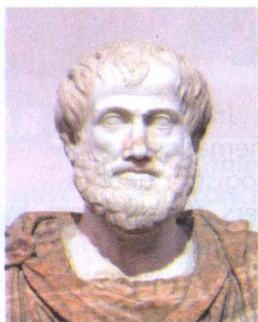
Why do we say that botany and medicine were well developed in ancient India?

There is evidence that the people of Ancient India had knowledge of botany and medicine even as far back as 2500 BC. The Rig Veda tells us about the action of light on plants, and during the vedic period, the medicinal properties of plants were known too. Later, botany evolved into medicine, and the science of agriculture. A document

dated about the 6th century BC describes the use of about 960 medicinal plants, and includes information on such topics as anatomy, physiology, pathology, and obstetrics. Ayurveda developed in India around 1500 BC, and of the earliest Ayurvedic treatises was the Sushruta Samhita which is attributed to the great physician Sushruta. He wrote on medicine, pathology, anatomy, midwifery, ophthalmology, biology, and hygiene.



From the available records, it is evident that major abdominal operations were also carried out. Charak, the great Hindu physician lived around 320 B.C. His teachings are compiled into what is known as "Charak Samhita" and it is also one of the classics of ancient Indian medicine.



Aristotle

Why is Aristotle called the most important biologist in ancient Greece?

Aristotle, the ancient Greek philosopher, combined his understanding of the natural world with his studies in philosophy, and began to draw conclusions about the state of matter and organisms. He stated that the function of an animal is intimately connected to its form. He concentrated on his studies in zoology. Aristotle attempted to classify animals, and identified about 540 species. He studied their anatomy, habits, and habitats. Aristotle made contributions to the theory of evolution too. He is properly recognized as the originator of the scientific study of life, and often called the father of biology.



Alcmaeon's Findings

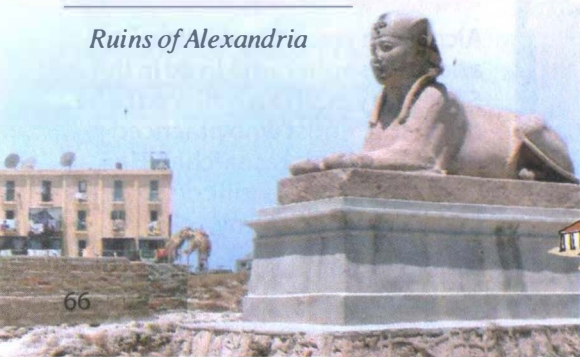
Alcmaeon was a Greek scientist and philosopher who lived in the 5th century BC. He is believed to be the first scientist who practiced dissection in his researches. He made the first scientific discoveries in the field of anatomy.

Why is the Library and Museum in Alexandria considered a major centre of biological development?

The ancient city of Alexandria boasted of impressive array of mathematicians, astronomers, doctors, biologists, geographers, mechanical engineers, theologians and thinkers. The native Egyptians had already developed a considerable expertise in medicine, astronomy, and engineering and the Greeks had led the world in advances in mathematics, biology, and philosophy. These trends converged in the new Greco-Egyptian port city of Alexandria. The city's Library and Museum became the world's first university and integrated scientific research complex.

Herophilus of Chalcedon was one of the most outstanding physicians from Alexandria, who recognized the brain as the centre of the nervous system. Pedanius Dioscorides wrote *De Materia Medica* in AD 77, the classical source of botanical terminology and pharmacology. Around this time, Pliny the Elder completed 'The Natural History'- a huge volume of work that dealt with different branches of biology.

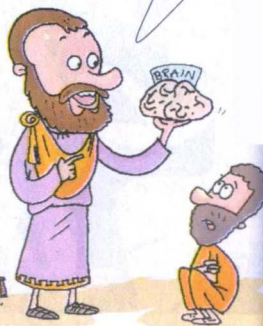
Ruins of Alexandria



Galen

Galen was a Greek physician who was one of the first to observe that the arteries carry blood, and not air, as was commonly believed at that time.

You are the centre of the world, sorry, nervous system!



Tell Me Why



Neurology

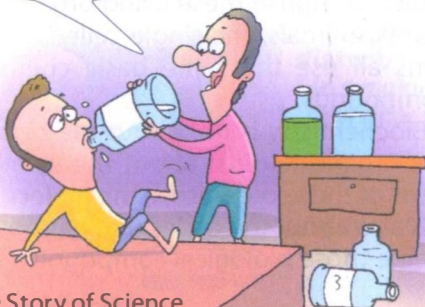
Neurology is the medical specialty concerned with the diagnosis and treatment of disorders of the nervous system, which includes the brain, the spinal cord, and the nerves. The 20th century witnessed great advances in neurology, and research by doctors and scientists greatly increased our understanding of the nervous system.

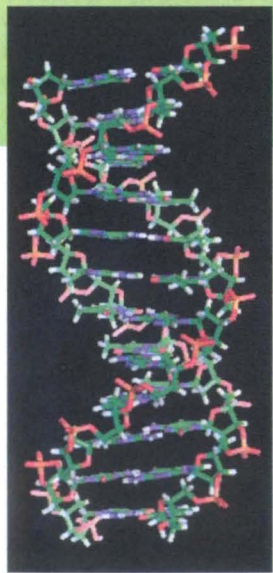
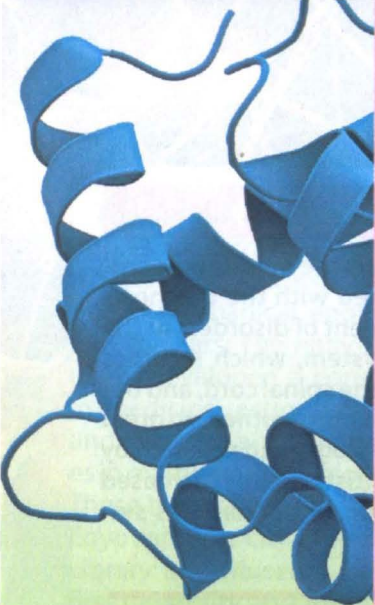
What is physiology?

Physiology is a branch of biology that deals with the mechanical, physical, and biochemical functions of living organisms. Physiology is concerned with the way the individual parts of an animal or human work, and how their workings affect other parts and the whole organism. Physiology is linked to anatomy and medicine.

The Alexandrian physician Herophilus undertook the first studies in human physiology around 300 BC. Modern animal physiology dates from the discovery of blood circulation in 1616 by William Harvey. The third branch of physiology is plant physiology.

I'm sure.
This medicine
will help you.





Timeline

- 1800 The term 'biology' is coined by Karl Friedrich Burdach
- 1859 Darwin publishes 'The Origin of Species'
- 1866 Mendel formulates the Laws of Inheritance.
- 1869 Miescher discovers nucleic acids in the nuclei of cells.
- 1918 Muller formulates the principles of spontaneous gene mutation.
- 1946 Melvin Calvin explains photosynthesis.
- 1953 Watson and Crick determine DNA is a double strand helix
- 1986 Wilson coins the term biodiversity
- 2000 Human Genome Project presents its preliminary results.

What is biochemistry?

Biochemistry is the science in which chemistry is applied to the study of living organisms, and the atoms and molecules which comprise these living organisms. Plants, animals, and single-celled organisms all use the same basic chemical compounds.

Biochemistry is not about the cells or the organisms- it is about the smallest parts of those organisms, the molecules. It is also about the cycles that happen to create those biological compounds. The

Why is the cell theory important in biology?

Robert Hooke, a scientist was observing dead cork samples through a simple microscope, when he noticed that they were made up of small, simple units that looked like the bare prison cells of his time. He called these units 'cells,' and his work launched a new frontier in scientific exploration that led to modern cell theory.

The Cell Theory states that all living things are made of cells which are reproduced from existing cells. It also states that cells are the basic units of structure, and function in living things. The modern version of the theory adds three more points. The first is that energy flow occurs within cells. The second point is that hereditary information is passed on from cell to cell, and the third point is that all cells have the same basic chemical composition.



Robert Hooke



cycles usually rely on enzymes and other proteins to move atoms and molecules.

The pharmaceutical industry depends greatly on biochemistry.



Genome

The human genome is like a blueprint for creating humans. Your genome contains all the information needed to create you, and to determine how your cells function throughout your whole life.

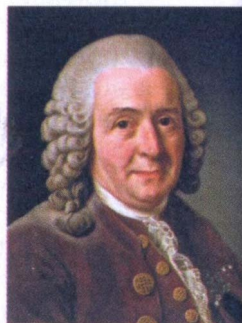
Carl Linnaeus

Carl Linnaeus established the system of taxonomy in which animals and plants are grouped by characteristics and relationship. Linnaeus classified living things within a hierarchy, starting with two kingdoms-the plant and animal kingdoms. This is the binomial system, in which each living thing is assigned a name consisting of two Latin words. The first word is the name of the genus, and the second is the species.

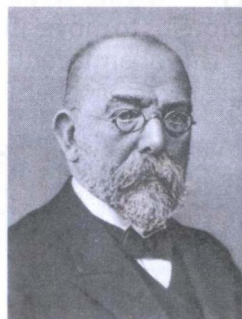
Why is the study of micro-organisms important to biology?

Micro-organisms make up the largest number of living organisms on the planet. There are three types of micro-organisms or microbes. They are bacteria, fungi, and viruses.

It was the great French chemist Louis Pasteur who demonstrated that there are micro-organisms everywhere. He believed that they were responsible for infectious diseases. He later developed effective vaccines against anthrax and rabies. Later, Robert Koch validated the germ theory of diseases. This led to the birth of a new branch of biology- bacteriology.



Carl Linnaeus



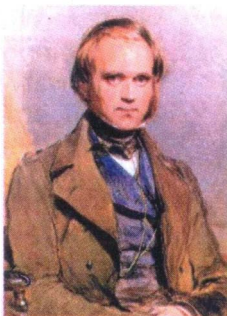
Robert Koch





John Ray

John Ray was a British researcher. In 1703, he established the six rules of plant classification. To this day, they remain the fundamental rules in this field. His work covers the taxonomy of about 18,600 species.

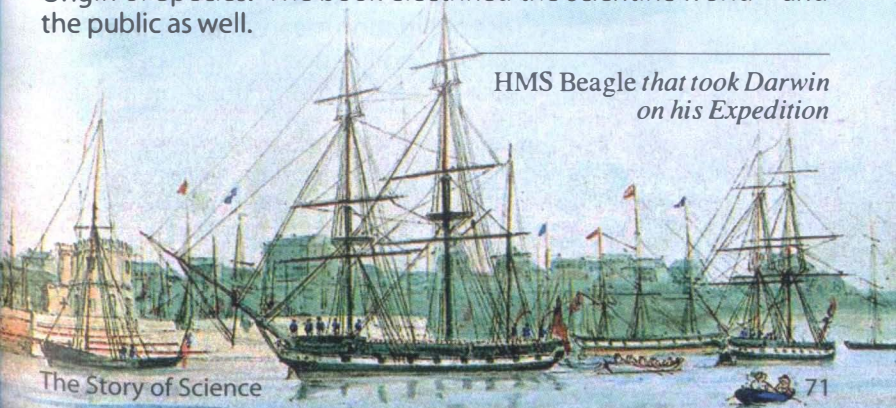


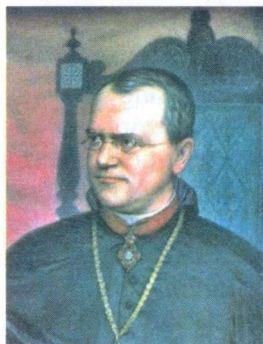
Charles Darwin

Why is Darwin an important figure in the history of biology?

During a five-year trip around the world, Darwin observed many forms of life. The strange plants, animals and fossils he had seen, showed that many forms of life were similar – but also slightly different. In the struggle to survive in a world of scarce resources, he reckoned that maybe the slightest difference would be helpful. Animals or plants with helpful differences would be the most likely to survive and pass along those differences to their offspring. Organisms with unhelpful differences would be more likely to die before they had offspring. Darwin called this 'natural selection,' which helped a species to evolve. In 1859, he spelled out his theory of evolution in a book titled 'On the Origin of Species.' The book electrified the scientific world – and the public as well.

HMS Beagle that took Darwin on his Expedition





Gregor Mendel

Why are William Harvey's contributions to biology important?

William Harvey is famous for having accurately described how blood circulates around the body, and the part the heart plays in this. Harvey was able to disprove the existing theory that the body made new blood, as it used up the old. He proved that the heart was a pump which forced the blood around the body through the arteries, and that the blood was returned to the heart through the veins. He also undertook research in embryology, and his contributions to biology remain significant to this day.

Why is Gregor Mendel called the 'father of genetics'?

In the 1860's, Gregor Mendel, an Austrian monk began experimenting with peas. Mr. Mendel wanted to find out how living things pass physical characteristics, also known as traits, from one generation to the next. By cross pollinating the pea plants, he carefully controlled which plants reproduced, and tracked how each of these traits was passed on from generation to generation. Cross pollination means that Gregor Mendel took pollination from a pea plant which he selected, and put it on another pea plant that he had also selected.

It was Mendel who first formulated the laws of inheritance of dominant and recessive traits. He called the fundamental unit of heredity an allele, which is very similar to the gene. Today, Mendel's work is world-renowned, and he is called the father of genetics.



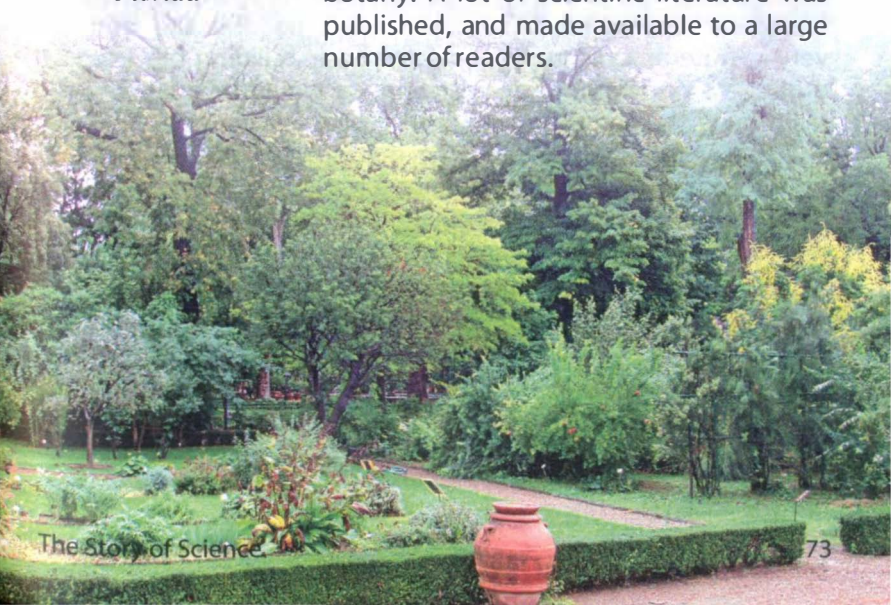


William Harvey

Why is it said that the Renaissance in Europe saw a Renaissance in botany too?

The Renaissance in Europe saw the re-birth of ideas, and of classicism. The first universities were founded, and the first botanical gardens like the University botanical gardens in Florence, Padua, and Pisa, were established. As a result, there was a widespread growth of botanical knowledge. European universities began to study plants not just by referring to manuscripts, but by studying living plants. Many famous botanists lived during this period. Luca Ghini from Italy is credited with being the first to press and dry plants in order to conserve them in a herbarium. The invention of the letterpress in 1455 led to a rapid spread of knowledge in all fields, including botany. A lot of scientific literature was published, and made available to a large number of readers.

*Botanical Garden of
Florida*



Ho! A terrifying world in a little drop!

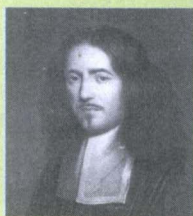


Why is Robert Hooke considered to be a great experimentalist?

Throughout most of human history, scientists knew very little about life, and how it works. It was not until 1665 that a scientist by the name of Robert Hooke used the microscope, and discovered the existence of cells. While using the newly invented compound microscope to look at a thin slice of cork,

Why did the invention of the microscope revolutionize biology?

Since the time of their invention, microscopes have allowed the exploration of an entire new world that is invisible to the naked eye. They have played a very important role as a tool in conducting biological researches. Microscopes made possible the study of very minute organisms. Cells are the basic building blocks in all organisms, and without microscopes we would be unable to explain even the simplest biological processes. It was Anton van Leeuwenhoek who invented the modern microscope in 1668. With the advent of electron microscopes, we can now even see the thinnest of cell walls. In short, microscopes have made visible the fascinating details of worlds within worlds.



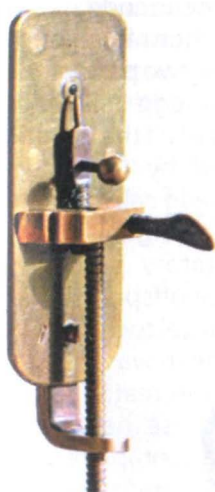
Marcello Malpighi

Marcello Marpighi was a physician who was one of the first to use the microscope- an invention that revolutionized anatomy. He was also the first to discover, and study human fingerprints.



Leeuwenhoek

Hooke saw tiny room-like structures that he named cells. In his book 'Micrographia', published in 1665, Hooke recorded his observations with the compound microscope of insects, sponges, bryozoans, foraminifera, and bird feathers. He was the first person to examine fossils with a microscope, and began the study of paleontology. Hooke correctly understood that fossils are the remains of living organisms. Hooke was perhaps the single greatest experimental scientist of the seventeenth century. His interests knew no bounds, ranging from physics and astronomy, to chemistry, biology, and geology, from architecture to naval technology.



*Leeuwenhoek's
Microscope*

Jean Lamarck

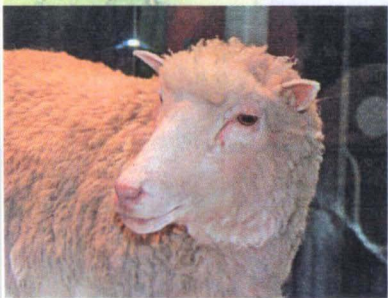
Jean Lamarck put forward the theory that acquired traits can be inherited. This theory is known as Lamarckism. He proposed that in Nature, it is the environment that produces changes. For example, he suggested that the length of the giraffe's neck can be attributed to generations of reaching up for food. Today, he is acknowledged as a forerunner of the theory of evolution.



Lamarck

Ecology and Environmental Science

Ecology is the study of organisms and the environments they live in. Ecologists study specific areas of biological activity called ecosystems. Environmental science usually involves the interface between ecological science and the human world, particularly in terms of public policy and natural resource economics.



Dolly

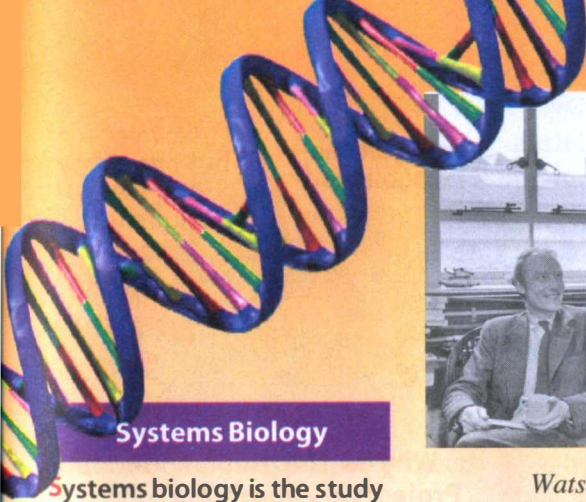
Why is cloning important in biology?

Cloning is the process of creating genetically identical copies of biological matter. Our bodies are made up of cells which have information to go about their work in the form of DNA or de-oxy-ribo-nucleic-acid. This is called the genetic code.

We all have grown from a single cell which contains these two parts of the DNA. It is called the egg cell. Since each cell has a copy of all the genetic information needed by the body, what we need is an egg cell to create an identical copy of an organism.

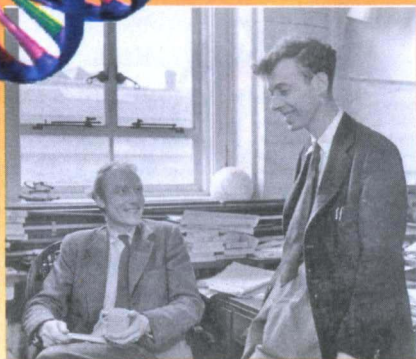
In cloning, laboratory processes are used to produce offsprings that are genetically identical to the donor parent. Dolly the sheep was the first cloned mammal to be created. Cloning is important, because the cloning of specific organs can completely do away with the need to transplant organs. Cloning can also help us to reproduce animals and prevent them from becoming extinct.





Systems Biology

Systems biology is the study of the network of genes, proteins and biochemical reactions that make up the human body. Understanding this network will help us understand an organism better- and this, in turn, will give us deeper insights into human health and diseases.



Watson and Crick

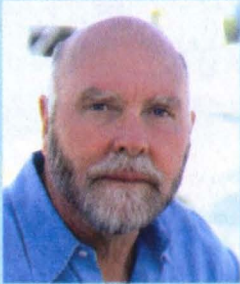
What do you know about the growth of molecular biology?

Molecular biology is the branch of biology that deals with the molecular basis of biological activity. The classical period of molecular biology began in 1953, with the discovery of the DNA double helix by James Watson and Francis Crick.

Once the structure of DNA was understood, the focus of molecular biology shifted to the mechanics of genetic replication and function. In the 1970's, molecular biologists developed a variety of techniques for manipulating genetic material. As molecular biology grew, it branched out into different fields like molecular cell biology, molecular evolution, and molecular medicine.

Mom, I'm going to be eco friendly. I quit using all wood products including my books.





John Craig Venter

The Creator

John Craig Venter is one of the central figures in the Human Genome Project. Using a fast sequencing technique, Venter and his colleagues were able to sequence the human genome, and the genomes of other organisms. This was a project parallel to the actual Human Genome Project. He also created the first cell with a synthetic genome in 2010.

Is your genome published?

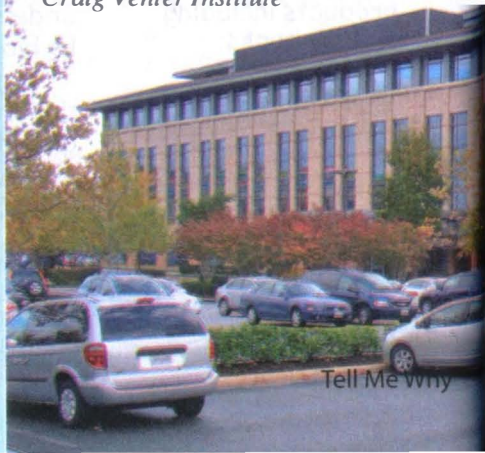
Not yet- but one of my stories is published.



Why is the Human Genome Project very important?

You know that the human genome is like a blueprint for creating humans. The Human Genome Project, which began in 1990, is an international scientific research project to map all of the human genes -30,000 in all - on the 46 chromosomes present in the DNA. The project also focuses on several non human organisms, and is one

Craig Venter Institute





Metabolomics and Proteomics

Metabolomics is the study of naturally occurring molecules called metabolites in biological materials. **Proteomics** is the large-scale study of proteins, particularly their structures and functions. Both metabolomics and proteomics are new and important emerging branches of science.

of the largest investigative projects in modern science.

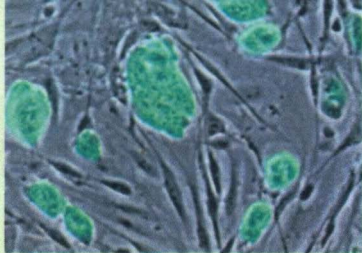
The Human Genome Project was completed in 2003. Although knowing the location of all of the human genes on the chromosomes is a monumental achievement, there is much more work to do before this information can be used to diagnose, or treat the occurrence of disease.

Why is genomics an important field of research?

Genomics is the study of genes and the functions. It aims at understanding the structure of the genome, including mapping of the genes, and sequencing the DNA.

Genomics includes the scientific study of complex diseases such as heart disease, asthma, diabetes, and cancer, because these diseases are typically caused more by a combination of genetic and environmental factors than by individual genes. It is an important field of study, because it can open the door to new possibilities for therapies and treatments for some complex diseases, as well as new diagnostic methods.

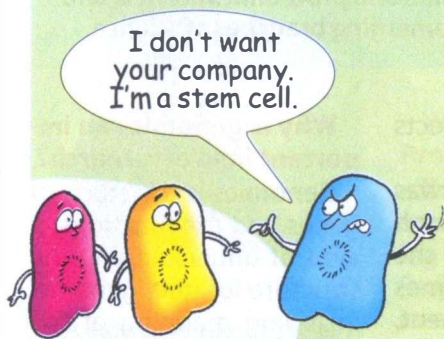




Stem Cells

Stem Cells

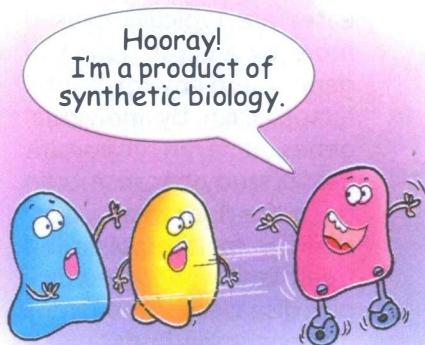
Stem cells are different from ordinary cells. A stem cell can make any one of the 220 different types of cells in the human body. There are two types of stem cells—embryonic stem cells, and adult stem cells. Adult stem cells are like built in repair kits that repair damaged or diseased cells in the body. Stem cells are important in that they have the potential to generate replacements for various body tissues and organs.

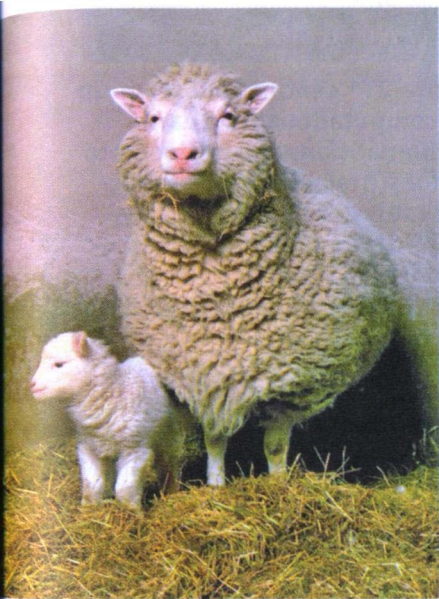


What is synthetic biology?

Synthetic biology is a mixture of engineering, biology, chemistry, and physics. The aim of synthetic biology is the design and construction of new biological functions and systems not found in nature. Researchers in California, for example, have created syn-

thetic circuits for yeast cells that produce a chemical called artemisinin, a key antimalarial drug, which will be cheaper than the existing ones. A US - Swiss group has engineered a genetic circuit designed to detect and destroy cancer cells without inflicting the unintended damage caused by chemotherapy and radiotherapy.

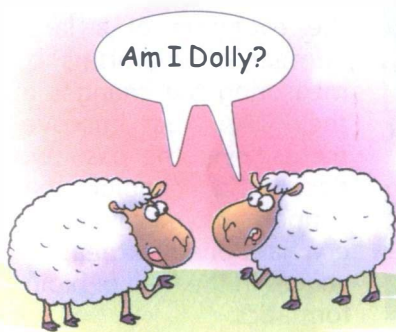




Dolly with its Kid

Why is Dolly the sheep a scientific landmark?

Dolly was an ewe, and the first mammal to have been successfully cloned from an adult cell. She was cloned at the Roslin Institute in Midlothian, Scotland, and lived there until her death when she was six years old. Dolly was cloned in 1996 from a cell taken from a six-year-old ewe. The technique that was made famous by her birth is somatic cell nuclear transfer, in which a cell is placed in an unfertilized egg. Considered one of the most significant scientific breakthroughs ever, Dolly's birth, and subsequent survival proved that adult cells can reprogramme themselves into a new being. Dolly gave birth to several lambs, and this proved that clones can reproduce. In the autumn of 2001, at the age of five, Dolly developed arthritis and began to walk stiffly, but this was successfully treated with anti-inflammatory drugs. Dolly died at age 6—earlier than a normal sheep would. As the first cloned mammal ever to be created from an adult cell, Dolly's place is secure in the history of human progress.





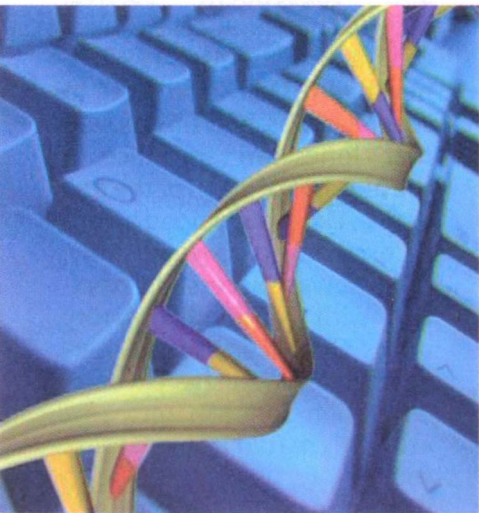
New World Biology

Biologists in the 21st century will team up with physical, computational, and earth scientists, mathematicians and engineers to find solutions for sustainable food production, ecosystem restoration, optimized bio-fuel production, and improvement in human health. New technologies and new fields of research will open up the ever widening horizons of biology, the science of life.

What is bioinformatics?

Bioinformatics is a branch of biology which deals with the study of methods for storing, retrieving, and analyzing biological data. It generates new knowledge about drug designing and development of new software tools. The goal of bioinformatics is to get new biological insights, and to try and identify the unifying principles

of biology. Using bioinformatic tools, researchers can compare the genomes of different species, and the similarities and differences among organisms. It has enabled researches to trace the evolution of a large number of organisms by measuring the changes in their DNA. Vast improvements, over the past two decades, in technology that supports biological discovery, have enabled great advances in the field of bioinformatics.

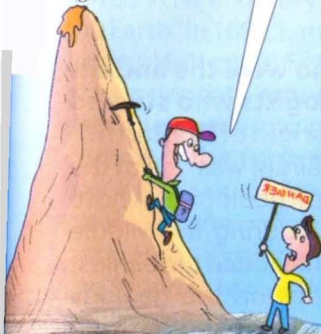


GEOLOGY

What is geology?

Geology is the science that studies the Earth. It deals with the surface features of the Earth, as well as with the structure and behaviour of every part of this planet. A geologist tries to understand the Earth's past by dating radioactive minerals and rocks, and by studying fossils which are the remains of shells, bones, and leaves. The study of geology is of great help in the search for fossil fuels like coal and petroleum, uranium, and other sources of atomic fuel.

I'm a geologist. I'm not afraid of volcanoes.



The word geology comes from two Greek words, 'geo' meaning 'earth' and 'logos' meaning 'study'.



Hot Core

We can learn about the temperature of the Earth from measurements taken from deep boreholes, mines, and from sediments in the ocean floor. It seems that the Earth's core is likely to be at temperatures around 7200°C . The radioactive decay of elements like uranium and thorium are a source of considerable heat at the core of the Earth.

Why is the Earth thought to be spherical in shape?

The shape of the Earth has intrigued scientists throughout history. Pythagoras of Samos, who lived between 580 and 500 BC, was probably the first to consider the possibility that the Earth might be a sphere. The first voyage around the world, led by Ferdinand Magellan, established that the Earth was a globe. The reason for the spherical shape of the Earth became clear when Isaac Newton formulated his law of gravitation.



Magellan

*Replica of
Magellan's Ship*

Who were the ancient geologists who studied the origin of the Earth?

Al Biruni was one of the earliest geologists, whose works during the Middle Ages included the earliest writings on the geology of India, hypothesizing that the Indian subcontinent was once a sea.

Oh my god,
Please keep the
shape of the Earth
as a sphere!



Avicenna was a famous Persian who theorized on the formation of mountains, origin of earthquakes, formation of minerals, and the diversity of the Earth's terrain.

William Whiston published 'A New Theory of the Earth' in 1696. Later, James Hutton, a Scottish scientist argued that the processes occurring in the Earth today had their counterparts in the ancient past. He is considered the founder of modern geology.



Laplace



Avicenna

Avicenna

During the Middle Ages, few scholars contributed more to science and philosophy than Avicenna. He wrote about astronomy, alchemy, medicine, and minerals, among other things, and theorized about weather and the formation of mountains and seas.

What is the Laplace hypothesis?

The first theories about the origin of the planets assumed that they were formed as part of the evolutionary history of the stars, or by an accidental collision between two stars. In 1776, these concepts changed with the French mathematician and astronomer Laplace's hypothesis that the solar system formed from a spinning cloud of gas. According to this hypothesis, the material that formed the Sun and planets was originally a disc-shaped rotating nebula, or cloud of hot gas. As the gas lost energy by radiation, and became cooler, the cloud would have shrunk inwards, and would have rotated more rapidly, until finally it stabilized to form the sun.



Secret of Earth's Interiors

In 1725, John Woodward, an English geologist, put forward the theory that the Earth had a molten centre surrounded by a thick crust. However, he failed to give a satisfactory explanation about how rocks were formed.



John Woodward

Why is the Earth's crust fascinating?

The earth is very, very old indeed- around 4.6 billion years old. It has a surface area of around 510 million square kilometers, and a radius of around 6,400 kms. Almost 70 percent of the surface area is water, as dry land accounts for just 29 percent of the surface. The earth is made of four distinct layers. These layers are the crust, the mantle, the outer core, and the inner core. The crust is made up of layers of sedimentary rocks, granite and basalt. The mantle is made up of superheated rock. It represents 85 % of the Earth's weight. The outer core is made up of super heated lava, while the inner core or centre of the earth is made of iron and nickel.

This rock is not suitable for construction.

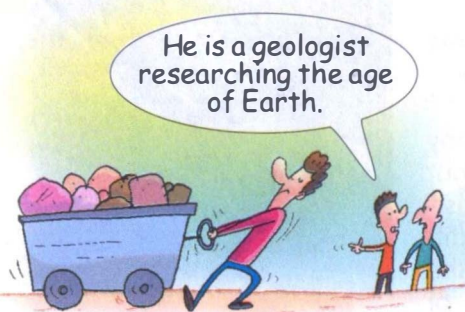


Shen Kuo



Shen Kuo

Shen Kuo was a great Chinese astronomer, mathematician, and scientist who suggested the theory of gradual climate change, and gave explanations for the process of land formation, based on his observation of fossil shells.



He is a geologist
researching the age
of Earth.

Why are rocks called the pages of the Earth's history book?

Almost all the Earth's history, to the extent that it is recorded, is recorded in rocks. The characteristics that rocks display are related in an orderly fashion to the processes that created the rock. The presence of fossil corals, or the shells of other marine organisms in a limestone indicates that it was deposited on the sea floor, and that what now is land, once lay beneath the waves.

Old lava flows represent the eruptions of ancient volcanoes, and vents that were active many millions of years ago. Beds of rock-salt point to the former existence of inland seas that evaporated in the sunshine. Seams of coal, which are the compressed remains of accumulations of peat, suggest widespread swamps and luxuriant vegetation. So, we can say that studying the way the Earth works now furnishes an understanding of the characteristics of rocks and the history they represent.

The Story of Science



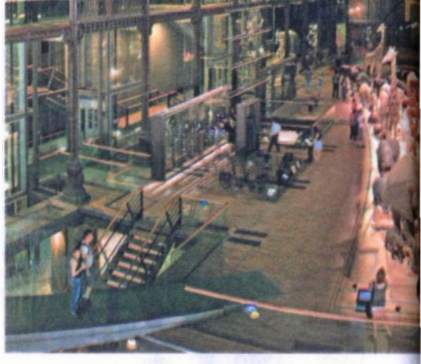
Fossil of a Fish

Fossils

Fossils are formed when a plant or animal dies and its soft body parts degrade, leaving behind harder parts as leaves, bones, and shells. These are important to us because fossils provide vital information about the history of the planet. Fossils provide information about the topography, the climatic conditions, animal culture, habitat, and other factors that prevailed during a particular era. Fossils are also an important tool in understanding evolutionary processes. They provide real physical evidence for processes that occurred millions of years ago.

Why did geology become an important branch of science in the 17th century?

The 17th century saw many questions being asked about how the Earth came into existence. The Bible gave many different interpretations, but the one constant factor in all of them was that the Earth was shaped by a Great Flood that swept over the planet. To prove this, a great deal of data on the Earth's composition was collected, and this in turn, led to the discovery of fossils. There was a heightened interest in the composition of the Earth, which in turn, led to increased curiosity about minerals and other components of the Earth's crust- and in the science of geology as a whole.



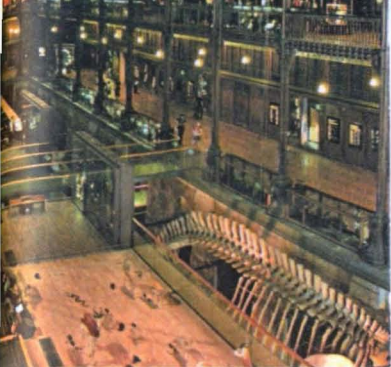
Why was the 19th century important for geology?

The 19th century saw many advances being made in geology. In England, a mining surveyor, William Smith, produced the first geological map of Britain. Many nations sought to expand their empires with explorations to distant lands. This gave naturalists like Darwin the opportunity to collect data on these voyages. In fact, Darwin's discovery of giant fossils helped



Geology

In the 18th century, mining became very important in Europe. Scholars began to study the makeup of the Earth in a systematic manner, and were eager to learn more about precious and semi precious metals. The term geology was first used professionally in publications by two naturalists, Jean Andre De Luc and Horace Benedict de Saussure. In 1741, the most well-known institution in the field of natural history, the National Museum of Natural History in France designated the first teaching position specifically for geology.



*Museum of Natural history,
France*

to establish his reputation as a geologist. Governments also supported geological research, because of the economic benefits involved in the discovery of precious metals and fossil fuels.



What do you know about geology in the 20th century?

In the 20th century, geology became increasingly important as the search for minerals, hydrocarbons, metals, gases and radioactive materials intensified. With the boom in the construction industry, the demand for minerals sky rocketed, for minerals are needed for the manufacture of cement and steel. The 20th century also saw an important development in geology- the theory of plate tectonics. This theory explains the cause of earthquakes, volcanoes, oceanic trenches, mountain range formation, and many other geologic features.

*Gallery of Paleontology,
Museum of Natural History*





Plate Tectonic Theory

The theory of plate tectonics - meaning 'plate structure' - was developed in the 1960's. This theory explains the movement of the rocky plates that form the Earth's crust. The plates are moving at a speed that has been estimated at 1 to 10 cms per year. Most of the Earth's volcanoes and earthquakes occur at the plate boundaries as they interact.



Alfred Wegener

Why is Alfred Wegener a significant figure in geology?

In 1915, the German geologist and meteorologist Alfred Wegener first proposed the theory of continental drift. According to this theory, the Earth's crust drifts on top of a liquid core. Wegener hypothesized that there was an original, gigantic super continent 200 million years ago, which he named Pangaea. Pangaea consisted of all of Earth's land masses. Pangaea started to break up into two smaller super continents, called Laurasia and Gondwanaland, during the period known as the Late Triassic. Later, these continents separated into land masses that

look like our modern-day continents. This theory is supported by the fact that the West African coastline, and the east coast of South America and the Caribbean Sea fit together like two pieces of a jigsaw puzzle. A similar fit also appeared across the Pacific.

I won't allow any more continents to drift!



Why is the sea floor spreading?

The sea floor spreading is the movement of two oceanic plates away from each other. As the plates move apart, the rocks break, and form a crack between the plates. Earthquakes occur along the plate boundary. Magma rises through the cracks, and seeps out onto the ocean floor like a long, thin, undersea volcano. As the magma meets the water, it cools and solidifies, adding to the edges of the sideways-moving plates. The magma piles up along the crack, and a long chain of mountains forms gradually on the ocean floor. This chain is called an oceanic ridge. An example of an oceanic ridge is the Mid-Atlantic Ridge. It is one part of a system of mid-oceanic ridges that stretches for 80,467 kilometres through the world's oceans. The underwater mountains of the ridge may be more than three and a quarter kilometres higher than the surrounding sea floor.

The Birth of Mountains

In the 19th century, the phenomenon of mountain formation was explained by a theory that the Earth was once a molten ball, and was now cooling. This cooling led to contraction and caused the surface to crack and fold on itself, pushing up the land above the cracks. However, this theory was later replaced by the theory of plate tectonics.

● *Sneha Rao*

A volcano is a vent in the Earth's crust from which molten magma, rock debris, and gases erupt. This creates new landforms near the vent. The word 'volcano' is derived from the name of the Roman God for fire, Vulcan.





Gypsum

Why are minerals important?

A mineral is a naturally occurring solid that has a characteristic chemical composition, a crystalline atomic structure, and specific physical properties. Minerals are extracted from the ground, and from rocks, as well as from river or sea beds. There are at present more than 4000 known minerals. Most minerals do not contain carbon. They can be divided into metallic, and non metallic minerals. Non-metallic minerals

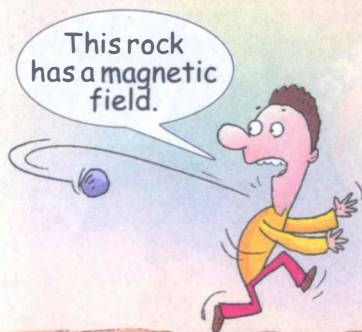
range from common clay to diamonds. Minerals are of great importance to us as they form a part of our everyday life. They are in almost everything we use, from the toothpaste we brush our teeth with, to the food that we eat. Minerals are also used extensively in industry, especially in the construction industry.



Paleomagnetism

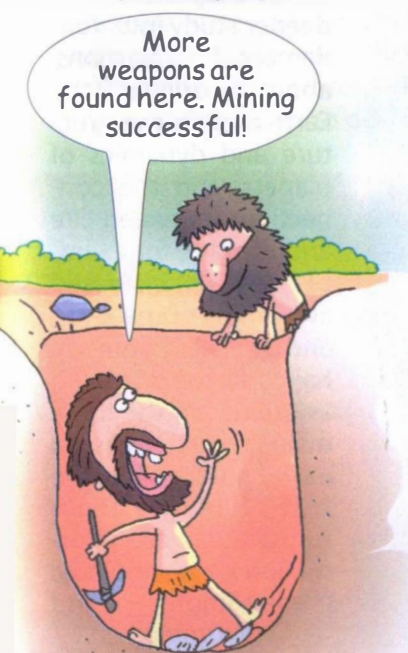
Paleomagnetism simply means the study of the Earth's magnetic field. This is done by studying the remaining traces of

magnetic minerals found within various rocks on the planet. In the 1950s geologists discovered that some rocks were magnetic- and this led to the science of paleomagnetism. The Canadian geologist Edward Irving is one of the key figures in the field of paleomagnetism.





Coal mine in Bihar



Why are coal mining and marine mining important in today's world?

Coal was the main energy source that fueled the Industrial Revolution of the 18th and 19th centuries. Coal deposits are found in sedimentary rock basins. Global coal production is expected to reach 7000 million tonnes per year in 2030.

The sea is rich in minerals. The most important mineral deposits on the sea floor are phosphorite and manganese nodules. Today, marine mining is one of the major areas of growth in mining.

Earthquakes

Earthquakes are the shaking, rolling or sudden shock of the Earth's surface. The intensity of earthquakes is measured on the Richter scale. An earthquake with magnitude above 7 on the Richter scale can cause huge devastation.

Surface Mining

Surface mining is a method of mining used to extract minerals and metals near the surface of the Earth. There are several types of surface mining, but the three most common are open-pit mining, strip mining, and quarrying.

What are the changes observed in 21st century geology?

In the 21st century, improved techniques in map making, increased data from satellites, and new technologies have all made it possible to learn more about places like the ocean floor and outer

space that were hitherto thought to be inaccessible. Geology in the 21st century will seek for deeper study into fundamental questions, about the origins of the Earth and life, the structure and dynamics of planets, and the connections between life and climate, for example. With the increased awareness of the Earth and the environment, has come the increased awareness of the three main thrust areas in earth studies for the 21st century. These thrust areas are information technology, oceanography, and global warming.



Tsunamis

A tsunami is a series of huge waves that can cause great devastation and loss of life when they strike a coast. Tsunamis are caused by an underwater earthquake, a volcanic eruption, a sub-marine rockslide, or, more rarely, by an asteroid or meteoroid crashing into the water from space. The word tsunami comes from the Japanese word meaning 'harbour wave'.

● *Radha Nair*

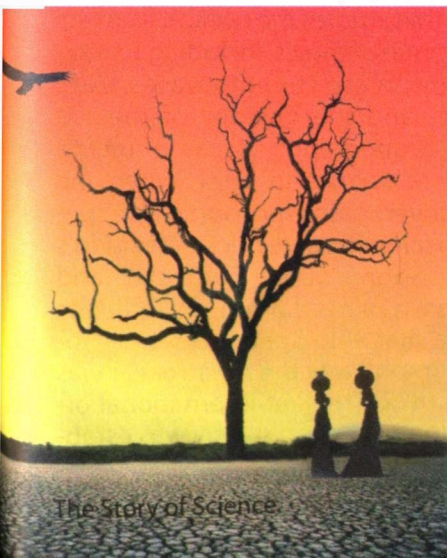


Remote Sensing

Remote sensing is the process of getting information about an object or phenomenon, without making physical contact with the object. For example, radar uses electromagnetic waves to identify the range, altitude, direction, and speed of both fixed and moving objects. Remote sensing makes it possible to collect data from dangerous, or otherwise inaccessible areas. Measuring instruments aboard satellites provide the global measurements for various data.

Why is the Geographical Information System a useful tool?

The Geographical Information System or GIS is a system designed to capture, store, analyze, manage, and present all types of geographical data. In a general sense, the term describes any information that integrates stores, edits, shares, and displays geographic information as an aid to decision making. The world's first operational GIS was developed in 1962 in Ottawa, Canada, by Dr. Roger Tomlinson. Public access to geographic information is mostly dominated by online resources such as Google Earth and interactive web mapping. The condition of the Earth's surface, atmosphere, and subsurface can be examined by feeding satellite data into a GIS. GIS technology is important, as it helps to examine the variations in Earth processes over days, months, and years.





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ISA

The ISA or International Seabed Authority was established in 1994 to organize and control all mineral-related activities in the international seabed area. Its headquarter is in Kingston, Jamaica. However, so far, deep sea mining has proved to be too costly to be a practical alternative to land-based mines.

What is oceanography?

Oceanography is the branch of earth science that studies the oceans. It covers a wide range of topics, including marine organisms, ocean currents, waves, plate tectonics and the geology of the sea floor. Oceanography became recognized as a science in 1871, when the British government sponsored an expedition to scientifically explore the world's oceans. Soon, other European and American nations started explorations too. The first ship specifically built for oceanography was the Albatross. It was built in 1882. The first international organization of oceanography was established in 1902.

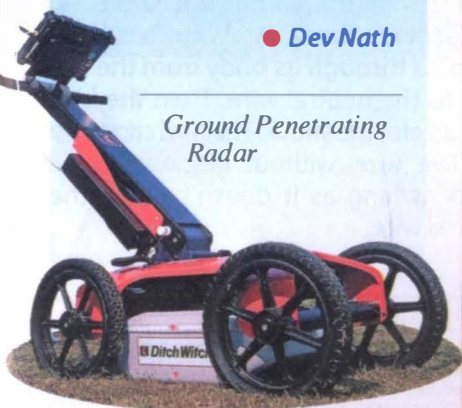


Ground Penetrating Radar

Ground penetrating radar uses radar pulses to get images from below the surface of the ground. It can be used to study rocks and soil, as well as other underground and underwater structures. It is very useful as it can detect objects, cracks, and changes in materials and structures such as roads and tunnels.

● *Dev Nath*

Ground Penetrating Radar



Clarifications & Corrections



Mr. Ram Kelker from Madhya Pradesh has come up with some important additional information, after reading our July issue, *Heritage Sites in India*.

* The Khajuraho town is in the Chhatarpur district of Madhya Pradesh. It is located about 620 kilometres south-east of New Delhi.

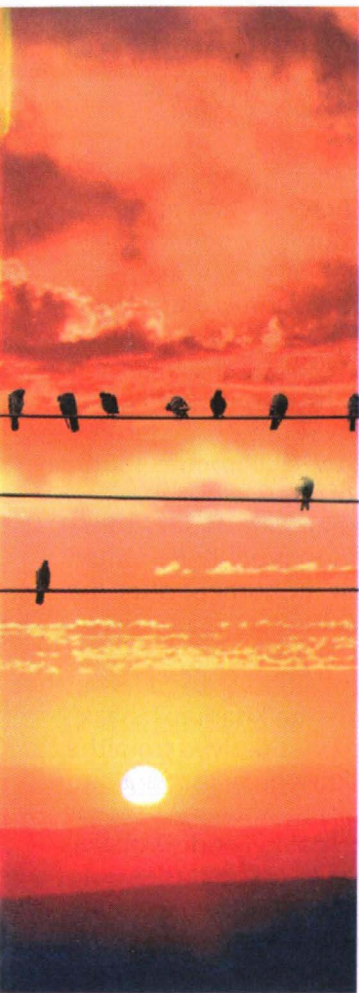
* Khajuraho is said to be the most frequently visited Indian monument after the Taj Mahal.

* The name Khajuraho is the modified form of its ancient name 'Kharjuravahaka', which was derived from the Sanskrit words 'kharjura' and 'vahaka'. 'Kharjura' means date palm and 'vahaka' means one who carries.

Thank you Mr. Kelker for the valuable information.

- Editor





I Wonder Why?

Question of the Month

Send us your questions

E mail: childrensdivision@mmp.in

Why does a bird not get an electric shock when it sits on a live wire?

A bird sitting on a live wire will get a shock only if the electric current passes through its body. We can compare the flow of electricity through a body to the flow of water. Like in a water flow, electric current always flows from a higher potential level to a lower potential level. The two wires in an electric post are kept in different potentials. One wire, which we call live, will be at a high potential, and it is the phase wire. The other wire is neutral and its potential is zero. On sitting on the live wire, the bird's potential will also be raised to the same potential as the wire's. If it comes in contact with the neutral wire, a current will pass through its body from the live wire to the neutral wire. Then the bird gets an electric shock. The bird can sit on the live wire without getting electric shock as long as it doesn't touch the neutral wire.

● Alwin George

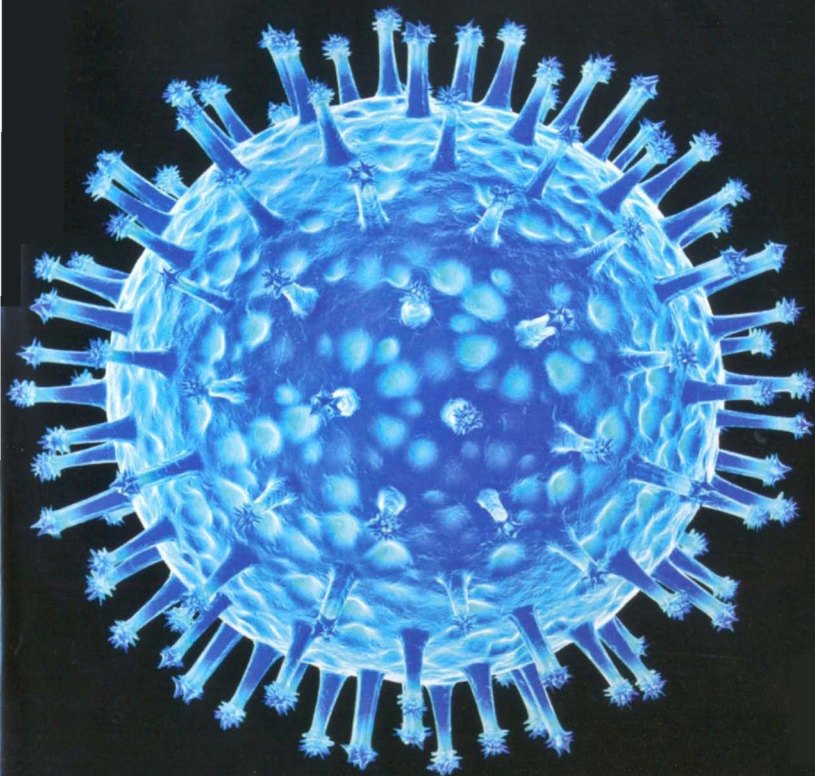
MANORAMA TELL ME WHY - THE STORY OF SCIENCE

Editor: Ammu Mathew

Editor-in-Charge: A.V. Harisanker*

Printed and Published by V. Sajeew George, on behalf of M.M. Publications Ltd,
P.B. No. 226, Kottayam - 686 001 at M.M. Publications Ltd, P.B. No. 226, Kottayam - 686 001
and Malayala Manorama Press, Kottayam - 686 039 and published from
M.M. Publications Ltd, P.B. No. 226, Kottayam - 686 001.

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BEAUTY OR BEAST ?

How nice the picture looks! Yet, in reality, it shows a monster most dangerous, even though it is so tiny that you need a highly powerful microscope to see it. It is the avian flu (bird flu) virus, which is responsible for the global pandemic.